Water Ethics and Water Resource Management

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Executive Summary

This report examines ethical issues associated with water resource utilization and management, including its uses in energy and other domains. Under the “Ethics of Energy Technologies in Asia and the Pacific” (EETAP) project, the Water Ethics working group has compiled case studies highlighting different ethical issues associated with water resource utilization and management. The report systematically discusses how water ethics can make a difference to water related practices to provide a cross-cultural review of the issues. The report reveals some gaps in existing knowledge to researchers, policy makers and funders of research, which could be used to examine further linkages between research and policy making, and presents areas of policy options to government policy makers.

The background to the report is presented in chapter 1. Water is the most essential substance upon which all life depends. Only the water made available for use in sufficient quantity and quality at a location over a period of time appropriate for an identifiable demand can be defined as “water resources”.

Climate change, rapid industrialization and urbanization, continuing population growth and mismanagement of water resources cause unprecedented water stresses. The access and use of water is reviewed in the second chapter of this report. Water is at the heart of many religions and culture. Cultural traditions, indigenous practices and societal values determine how people perceive and manage water, and provide useful references for water ethics construction.

The third chapter of this report examines some possible ethical principles to resolve moral dilemmas involving water.

Existing problems in current water management practices are listed in the fourth chapter. Transformation of human water ethics has the potential to be far more effective, cheaper and acceptable than some existing means of “regulation”, but transformation of personal and societal ethics need time because the changes to ethical values are slow.

Policy options are discussed in the fifth chapter with some examples. This draft especially welcomes more suggestions and experience in review.

Appendices include seven case studies conducted by the members of the working group from perspectives of different fields. The construction of water ethics needs joint effort and interdisciplinary collaboration from all at all levels. By following certain general principles, adopting scientific methods and tools, arousing experts, stakeholders and decision makers’ responsibility, and conducting ethical education for young people, the construction of ethically acceptable water utilization and management system can be expected to occur in the near future.
1. Background

1.1 Water Basics

Water is an essential substance upon which all life depends. Where there is water there is life, and where water is scarce, life has to struggle. 75% of the earth’s surface is covered by water, as the saying goes “water, water, everywhere”. The distribution of water on the Earth, is represented in Figure 1. The left-side bar shows where the water on Earth exists; about 97% of all water is in the oceans. The middle bar shows the distribution of freshwater that is only 3% of all Earth’s water. However, the physical state of water, including the freshwater, is not all liquid. Nearly 69% is locked up in glaciers, icecaps and permanent snow cover of both poles, mountainous regions and in Greenland. Land based glaciers affect stream flow quantity and provide water resources to the lowland regions. While 30% of freshwater comes from groundwater.\(^1\) Only 0.3% of the freshwater on Earth is contained in river systems, lakes and reservoirs, which are the water we are most familiar with and is the most accessible water source to satisfy human needs in our daily lives.

![Distribution of Earth’s Water](http://ga.water.usgs.gov/edu/earthwherewater.html)

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\(^1\) Including underground water such as deep aquifers rather than subsurface water, which is often included as surface water
Even though three quarters of the earth’s surface is covered by water, not all of that water is available for human uses. Figure 2 shows that more than 99% of all water (oceans, ice, most saline water and atmospheric water) is not available for our uses. Even of the remaining fraction of 1%, much of that is stored in the ground. Surface water sources (such as rivers and lakes) only constitute 0.0067% of the total water.

![Figure 2: Earth’s Water Available for human uses (Source: USGS http://ga.water.usgs.gov/edu/earthwherewater.html)](image)

Here we can see that water is generally classified into surface water and groundwater. Surface water is water found in a river, lake or other surface impoundment. Surface water is exposed to many different contaminants, such as animal wastes, pesticides, insecticides, industrial wastes, and many other organic materials. Groundwater is the part of precipitation that infiltrates down through the soil until it reaches rock material that is saturated with water. Water in the ground is stored in the spaces between rock particles, and slowly moves underground, generally at a downward angle, and may eventually seep into streams, lakes and oceans. Groundwater is not always accessible, and sometimes is difficult to locate or to measure and describe. Compared to surface water, groundwater is not as easily contaminated, but once it is contaminated, the full remediation and recovery is not easily achieved.

Surface water and groundwater, are often correlated and can be transformed to each other within the water cycle, which is also known as the hydrological cycle. This is the continuous movement of water on, above and below the surface of the Earth (Figure 3). Surface and ground water cycles are only part of global cycle of water including the evaporation. There is no starting or ending point of the water cycle, and water can change states among liquid, vapor and ice at various places in the cycle.

Water is not in a static condition but there is a dynamic “exchange” of water among the

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2 We note that “deep” or “fossil” aquifers are not usually linked with any of the surface water, unless they are extracted by humans for present uses.
ocean, land and atmosphere. The turnover of water involves water evaporation and precipitation processes. The turnover of the Earth’s water estimates as 577,000 cubic km per year (Shiklomanov 1996) and about 40% of precipitation that falls on land comes from ocean derived evaporation and 60% from land surface (Figure 3). These large volumes of water illustrate the key role that precipitation plays in renewing water resources, especially recharging the ground water which is the main source of freshwater and supporting both rainfed agriculture and ecosystem.\(^3\) The dynamics and value of full renewal of water, full replenishment, depends on water volume and its dynamics. It is estimated that the full renewal time of the ocean may take 2,500 years, ground water 1,400 years, ground ice of the permafrost zone 10,000 years, polar ice 9,700 years, mountain glaciers 1,600 years, lakes 17 years and 8 days for atmospheric moisture (Shiklomanov 1996). The times vary with climatic conditions, which are rapidly changing now.

![The Water Cycle](http://ga.water.usgs.gov/edu/watercycle.html)

**Figure 3: The Water Cycle (Source: USGS)**

### 1.2. Preface to the report

The report is the product of international collaboration between members of a working group on “Water Ethics and Water Resource Management” formed under the UNESCO “Ethics of Energy Technologies in Asia and the Pacific (EETAP)” project. The EETAP project is coordinated by the Regional Unit in Social and Human Sciences in Asia and the Pacific (RUSHSAP) at UNESCO Bangkok, and is linked to several key activities of UNESCO Social and Human Sciences sector, including the ethics of science and technology, environmental ethics, philosophical dialogues, linking research with policy-making and promoting the culture of peace.

The work also feeds into considerations of the ethics of climate change that are being made by the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST). The work builds upon some earlier COMEST reflections on water ethics and a

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\(^3\) Refer to World Water Development Report 2.
growing body of discussion on the topics of water ethics. The EETAP project\textsuperscript{4} calls for developing dialogues within each participating country and between countries on the results of research, future research needs, policy lessons and policy recommendations in regard to the ethical issues of energy-related technologies and related environmental and human security issues. The conclusions of this report are applicable to all human uses of water, not only those related to direct use in energy production, or indirect use such as in energy intensive agricultural production systems.\textsuperscript{5}

On 7 November, 2007 and 22–23 October, 2008, the 1\textsuperscript{st} and 2\textsuperscript{nd} Joint UNESCO-Peking University International Symposia on Water Ethics were held in Beijing, China. The symposia were one of the activities of the working group providing a platform for all the participants to discuss water ethics and how more ethical water resource management could be constructed. This working group report started through building upon the major points that had been discussed during those two meetings and some of the case studies are based on the papers submitted by the working group members.

The aim of this report is to illustrate how water ethics can make a difference to water related practices. The purpose is to reveal gaps in existing knowledge to researchers and funders of research, to examine linkages between research and policy making, to provide a cross-cultural review of the issue, to educate readers on water ethics, and to present policy options to government policy makers at all levels.

The major focus of the WG14 is to study the ethical issues associated with water resource utilization and management, including its uses in energy and other domains in many countries. The second chapter of this report examines some possible ethical principles to resolve moral dilemmas involving water. The access and use of water is reviewed in the third chapter of this report. Existing problems in current water management practices are reviewed in the fourth chapter, revealing the need for a revision of our Water Ethics. Policy options are discussed in the fifth chapter with some examples. Appendices include six case studies and additional materials for readers conducted by experts in different fields.

Water has deep meanings for people, and by exploring this relationship we may not only understand more the relationship between living organisms, people and the environment, for aquaculture, fishing, and enjoyment, but also we may understand more of ourselves. In the global age we live in, the question of the common oceans and the required diplomacy

\textsuperscript{4} The formal launch to the EETAP project was the Conference on Ethics of Energy Technologies in Asia and the Pacific held in Bangkok September 26–28th, 2007. After the conference, 14 cross-cultural and multidisciplinary working groups were emerged to take the project forward. Those include (1) Universalism and environmental values; (2) Ethical worldviews of nature; (3) Visions and hopes of the future; (4) Representation and who decides; (5) Community engagement; (6) Stakeholder responsibilities; (7) Energy equity and human security; (8) Cost-benefit analysis and economic constructions; (9) Adoption and development of energy technologies; (10) Ethical frameworks for research agendas and policy; (11) Educational frameworks for environmental ethics; (12) Nuclear dialogues; (13) Energy flow, environment and ethical implications of meat production; and (14) Water ethics and water resource management.

\textsuperscript{5} Please refer to WG13 report of the EETAP project on “Energy flow, environment and ethical implications of meat production”.
provides very important precedents and lessons for future global planning. It also provides a precedent for protecting biodiversity that is increasingly being recognized on the land too. We hope that the report can offer guidance to governments and people in decision-making that is necessary for our use of water and our very survival.
2. Water and Life

2.1 Uses of Water

Although humans use sea water and oceans in many ways, including transport, a reservoir for dumping pollution, and for recreation, this report focuses on fresh water. Uses of water can be categorized as consumptive and non-consumptive. A use of water is consumptive if that water is not immediately available for another use. Losses to sub-surface seepage and evaporation are considered consumptive, as is water incorporated into a product. Water that can be treated and returned as surface water, such as sewage, is generally considered non-consumptive if that water can be put to additional use. The competing water uses for main income groups of countries are shown in Figure 4.

![Competing water uses for main income groups of countries. (Source: UNESCO, 2003)](image)

**Agricultural Water Use**

It is estimated that 69% of world-wide water use is for irrigation, and this number is even higher in low and middle income countries (Figure 5). The effective use of water is an ethical issue that could reduce the water usage related to crop and animal production (Appelgren, 2004). Between 15-35% of irrigation withdrawal is unsustainable. In some areas of the world irrigation is necessary to grow any crop, in other areas it permits more profitable crops to be grown or enhances crop yield. Various irrigation methods involve different trade-offs between crop yield, water consumption and capital cost of equipment and structures. Irrigation methods such as most furrow and overhead sprinkler irrigation are usually less expensive but also less efficient, because much of the water evaporates or runs off. More efficient irrigation methods include drip or trickle irrigation, surge irrigation, and some types of sprinkler systems where the sprinklers are operated near ground level. These types of systems, while being more expensive, can minimise runoff and evaporation.
Aquaculture is a small but growing agricultural use of water. Freshwater commercial fisheries may also be considered as agricultural uses of water, but have generally been assigned a lower priority than irrigation. This will be further discussed in case study 1—“the need for a more efficient aquaculture industry” in the annex.

As global populations grow, and as demands for food increases with a fixed water supply in the world, there are efforts underway to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types and water monitoring. For example, if we find synthetic materials require less water to produce (which is not usually the case now), there may be a shift from use of natural fibres such as cotton and wool.

**Industrial Water Use**

It is estimated that 15% of world-wide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectricity plants, see 3.3), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. The portion of industrial water usage that is consumptive varies widely, but as a whole is lower than agricultural use.

**Household Water Use**

The world-wide water use for household purposes is also around 15%. These include drinking water, bathing, cooking, sanitation and gardening. Basic household water requirements have been estimated by Peter Gleick (2006) at around 50 litres per person per day, excluding water for gardens. Of these 50 litres, he estimated 2L for drinking, 20L for sanitation services, 15L for bathing, and 10L for cooking and kitchen. However, if we examine the water consumption for food and energy in most countries, these exceed the direct consumption of water.

**Recreational Water Use**

Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is often tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Release of water from a few reservoirs is also timed to enhance whitewater boating, which also could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers. There is significant use of the oceans for recreation also.

Recreational usage is usually non-consumptive. Golf courses are often targeted as using excessive amounts of water, especially in drier regions. Additionally, recreational usage may reduce the availability of water for other users at specific times and places. For example, water retained in a reservoir to allow boating in the late summer is not available to farmers during the spring planting season. Water released for whitewater rafting may not be available for hydroelectric generation during the time of peak electrical demand.

**Environmental Water Use**

Environmental water use is use of water for the benefit of ecosystems or the environment, rather than for human benefit. Explicit environmental water use is a very small but growing
percentage of total water use. Environmental water usage includes artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders around dams, and water releases from reservoirs timed to help fish spawn. Like recreational usage, environmental usage is non-consumptive but may reduce the availability of water for other users at specific times and places. We can expect an increase in this use as biocentric and ecocentric value systems are adopted more.

2.2 Water for Energy Production

Water is used in a number of energy production systems, as a coolant, or driver of turbines. Hydroelectricity generation and the dam building business have generated significant debate for the land use and modification of the natural environment (Thein, 2007). We can classify the schemes into large and small hydropower and sustainable hydropower.

The World Commission on Dams (2000) was established to provide guidance, and it declared that there are five core values: equity, sustainability, efficiency, participatory decision making and accountability. The report also outlined seven strategic principles, which may be appropriate to many energy production systems. These are:
1. Gaining public acceptance
2. Comprehensive Options Assessment
3. Addressing Existing Dams
4. Sustaining Rivers and Livelihoods
5. Recognizing Entitlements and Sharing benefits
6. Ensuring Compliance
7. Sharing rivers for peace, development and security

United Nations Environment Programmes have also become involved in these debates at times. A common recognition for basic principles, guidelines and recommendations has been reached on paper but still there are numerous controversies especially over large hydropower schemes. A significant amount of arguments from different aspects, research materials, case studies and critical thoughts has been documented. At present the focal point of the debate has shifted from ‘whether or not to build dams’ to ‘how best to do it properly’.

Traditionally, the engineering ethics in dam construction only focused on technical feasibility and financial accountability. The moral or ethical obligation of individual professionals and corporations towards society and environment was neglected.

2.3. Water Resources, Availability and Stress

The permanent motion of water from liquid to solid, gaseous states (and vice versa) and its extensive and variable dynamics of turnover, make water resource assessment a complicated, time consuming and complex task. Water resource assessment is not limited to physical or quantitative measures but also considers its qualitative values. Freshwater is not always renewable, like deep or fossil aquifers and not all freshwater is accessible for use. Therefore, it is important to distinguish available water resource from natural water resource, actual or manageable water resource, when freshwater flows out to the sea, from renewable water resources.

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6 Refer to case studies of dam construction in EETAP WG4 and WG5 reports.
Clarifying these two definitions would help us figure out how much water can be really utilized by human beings. According to UNESCO and WMO, “Water resources” is defined as water available, or being made available, for use in sufficient quantity and quality at a location over a period of time appropriate for an identifiable demand. Here two definitions - “water storage” and “water resources amount” - should be differentiated: not all water stored on the Earth can be called “water resources”, and only those available water with sufficient quantity and quality that can satisfy certain demands and uses can be called “water resources”.

The earliest comprehensive assessment of the global water resources dates back to the 1970s. The First World Conference on Water Resources (Argentina, 1978) also contributed in global initiatives and cooperation, urging the international community to strengthen its coordination on global water resource assessment. Since then a number of initiative have been taken to compile or compare existing data on water resource, among them most recent and often referred are FAO’s global information system on renewable water resources (Aquastat programme started from 1994) and Shiklomanov from the Russian Federation, State Hydrological Institute of the Russian Federation, who was assigned to lead UNESCO-IHP project on water assessment (1991-1996).

FAO’s Aquastat is a database on a water resources based on an accounting approach: the total renewable water resources (TRWR) of a country which consist of the internal renewable water resources (IRWR) plus external water resources. The IRWR are the amount of water generated inside a country, and the ERWR are the amount of water generated in upstream countries. Shiklomanov’s data compilation on freshwater resource is based on net balance approach, natural water resource minus demand of principal sectors of water use.

Overall, freshwater resources are sufficient to satisfy human needs. However, due to uneven distribution across the regions, countries and among the countries or across different sectors that uses water, there is a conflicting and competing interest over the freshwater. Different indicators are used to estimate the distribution of freshwater resources and to define water stress. The European Environmental Agency’s definition of water stress is when the demand for water exceeds the available amount during a certain period or poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers etc.,) and quality (eutrophication, organic matter pollution, saline intrusion etc.).

The most widely used measure is the Falkenmark indicator or “water stress index” (Falkenmark, Lundqvist and Widstrand, 1989). They proposed 1,700m$^3$ of renewable water resources per capita per year as the threshold, based on estimates of water requirements in the household, agricultural, industrial and energy sectors, and the needs of the environment. Countries whose renewable water supplies cannot sustain this figure are said to experience water stress. When supply falls below 1,000m$^3$ a country experiences water scarcity, and

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below 500m$^3$, absolute scarcity.$^8$

The freshwater resources per capita of the world are shown in Figure 5. According to the map, the fresh water resources per capita of the world are the maximum 10,000 cubic meters or more in South America, Russia, Australia and some parts of Africa. Algeria, Libya, Saudi Arabia, Yemen, Oman, Jordan are places where fresh water resources per capita are less than 1000 cubic meters.

![Fresh Water Resources Per Capita of THE WORLD](http://www.mapsofworld.com/world-freshwater-resources.htm)

Figure 4: Fresh Water Resources Per Capita of the World (Source: http://www.mapsofworld.com/world-freshwater-resources.htm)

Based on Shiklomanov’s method of water resource calculation, the net balance between natural water resource minus withdrawals for the demand of principal sectors of water use, developed a water resource vulnerability index. According to this index a country is in water scarcity if its annual withdrawals are between 20-40% of annual supply, and severely water scarce if this figure exceeds 40%. The main factor behind this is fast growing populations. From Figure 4 it can be seen that freshwater distribution around the world is quite uneven. The Middle-East and some countries of Africa face acute water shortage (Wolf, 2001). Freshwater resources are finite and should be used properly to avoid its shortage in the future.

According to the World Business Council for Sustainable Development, water stress applies to situations where there is not enough water for all uses, whether agricultural, industrial or domestic. Defining thresholds for stress in terms of available water per capita is more complex, however, entailing assumptions about water use and its efficiency. Nevertheless, it has been proposed that when annual per capita renewable freshwater availability is less than 1700 cubic meters, countries begin to experience periodic or regular water stress. Below 1000 cubic meters, water scarcity begins to hamper economic development and human health and well-being.

**Population growth**

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$^8$ Frank R. Rijsberman “Water Scarcity: Fact or Fiction?”. 
In 2000, the world population was 6.2 billion. The UN estimates that by 2050 there will be an additional 3 billion people with most of the growth in developing countries that already suffer water stress. Thus, water demand will increase unless there are corresponding increases in water conservation and recycling of this vital resource (Wolf, 2001).

**Increased affluence**

The rate of poverty alleviation is increasing especially within the two population giants of China and India. However, increasing affluence inevitably means more water consumption: from needing clean fresh water and basic sanitation service, to demanding water for gardens, car washing or private swimming pools.

**Expansion of business activity**

Business activity ranging from industrialization to services such as tourism and entertainment continues to expand rapidly. This expansion requires increased water services including both supply and sanitation, which can also lead to more pressure on water resources and natural ecosystems.

**Rapid urbanisation**

The trend towards urbanisation is accelerating. Small private wells and septic tanks that work well in low-density communities are not feasible within high-density urban areas. Urbanisation requires significant investment in water infrastructure in order to deliver water to individuals and to process the concentrations of wastewater – both from individuals and from business. These polluted and contaminated waters must be treated as they pose unacceptable public health risks.

**Climate change**

Climate change could have significant impacts on water resources around the world because of the close connections between the climate and hydrological cycle. Rising temperatures will increase evaporation and lead to increases in precipitation. Both droughts and floods may become more frequent in different regions at different times, and dramatic changes in snowfall and snowmelt are expected in mountainous areas. Climate change could also mean an increase in demand for irrigation, garden sprinkler and even swimming pools.

**Depletion of aquifers**

Due to expanding human population, competition for water is growing such that many of the world’s major aquifers are becoming overdeveloped. This is due both to direct human consumption as well as agricultural irrigation by groundwater. Millions of pumps of all sizes are currently extracting groundwater throughout the world. Irrigation in dry areas such as northern China and India is supplied by groundwater, and is being extracted at an unsustainable rate. Cities that have experienced aquifer decline between 10 to 50 meters

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include Mexico City, Bangkok, Manila, Beijing, Madras and Shanghai.\textsuperscript{10} In many places of the world, groundwater is being used at a faster rate than it can be replenished. Even if some water remains available, it costs more and more to capture it.

**Water Pollution**

Water pollution is one of the main concerns of the past few decades, which aggravates water stress, and this issue will be revisited in the chapter on water management. The governments of many countries have striven to find solutions to reduce this problem through policy measures such as polluter pays and fines, to overcome usage patterns underlying the pollution.

2.4. Water and Conflict

Water has been the source of various conflicts throughout history. Political water stresses arise when water scarcity causes political tensions. Water stress has led most often to conflicts at local and regional levels (Trondalen & Munasinghe, 2004). Water stress can also exacerbate conflicts and political tensions, which are not directly caused by water. Gradual reductions over time in the quality and/or quantity of fresh water can add to the instability of a region by depleting the health of a population, obstructing economic development, and exacerbating larger conflicts.

Conflicts and tensions over water are most likely to arise within national borders, in the downstream areas of distressed river basins. The case study 2 gives a good example of such a conflict in Southern China. Areas such as the lower regions of China’s Yellow River or the Chao Phraya River in Thailand, for example, have already been experiencing water stress for several years. Additionally, certain arid countries which rely heavily on water for irrigation, such as China, India, Iran, and Pakistan, are particularly at risk of water-related conflicts.

Technology has allowed humans to exploit natural resources better in order to increase food production, however, there are a finite number of resources on the planet, therefore there is an upper bound to the amount of food that can be produced. Similarly, there is an upper bound to the amount of humans the planet can support as humans depend on food production, and the resources to sustain that. As societies get closer to these limits, we can expect more conflicts to emerge.

2.5. Water, Culture and Religion

The above sections review water basics, water uses and water stresses, mainly from a scientific aspect. The 2006 World Water Day (WWD) theme was “Water and Culture”, which has drawn attention to the fact that there are as many ways of viewing, using and celebrating water according to different cultural traditions. Water is at the heart of many religions and is used in different rites and ceremonies – often being held sacred. Water has also been represented in art for centuries – in music, paintings, writing and film. Cultural traditions, indigenous practices and societal values determine how people perceive and manage water, and provide useful references for water ethics construction.

\textsuperscript{10} Groundwater – the processes and global significance of aquifer degradation
11 The UNESCO Water Portal Weekly Update No.122 published in December 2005 the following facts and figures about water religions and beliefs:

1. Water plays a central role in many religions and beliefs around the world: water is the source of life and represents (re)birth. Water cleans the body and by extension purifies it. These two main qualities confer a highly symbolic – even sacred – status to water. Water is therefore a key element in ceremonies and religious rites.

2. Water is often perceived as a god, goddess or divine agency in religions. Rivers, rain, ponds, lakes, glaciers, hailstorms or snow are some of the forms water may take when interpreted and incorporated in cultural and religious spheres.

3. Religious water is never neutral and passive. It is considered to have powers and capacities to transform this world, annihilate sins and create holiness. Water carries away pollution and purifies both in a physical and symbolical sense. Water is a living and spiritual matter, working as a mediator between humans and gods. It often represents the border between this world and the other.

In Buddhism, water is used in Buddhist funerals. It is poured and overflows into a bowl placed before the monks and the dead body. As it fills and pours over the edge, the monks recite “As the rains fill the rivers and overflow into the ocean, so likewise may what is given here reach the departed.”

In Christianity, water is intrinsically linked to baptism, a public declaration of faith and a sign of welcome into the Christian church. When baptized, one if fully or partially immersed in water, or one’s head may simply be sprinkled with a few drops of water. The sacrament has its roots in the Gospels, wherein it is written that Jesus was baptized by John the Baptist in the River Jordan. In baptism, water symbolizes purification, the rejection of the original sin.

In Hinduism, water is imbued with powers of spiritual purification for Hindus, for whom morning cleansing with water is an everyday obligation. All temples are located near a water source, and followers must bathe before entering the temple. Many pilgrimage sites are found on river banks; sites where two or even three rivers converge are considered particularly sacred. Hindu pilgrims travel thousands of miles to collect a bottle of water from the headwaters of the sacred Ganges River, and they proudly display the bottle in their homes for the rest of their lives. An important part of ritual purification in Hinduism is the bathing of the entire body, particularly in rivers considered holy. In Varanasi, India, 60,000 Hindus bathe in the Ganges River every day.

In Islam, water serves above and beyond all for purification. The first and most important involves washing the whole body. It is obligatory after sex, and recommended before the Friday prayers and before touching the Koran. Before each of the five daily prayers, Muslims must bathe their heads, wash their hands, forearms and feet. All mosques provide a water source, usually a fountain, for this ablution. When water is scarce, followers of Islam use sand to cleanse themselves, and this is the third form of ablution.

In Judaism, Jews use water for ritual cleansing to restore or maintain a state of purity. Hand-washing before and after meals is obligatory. Although ritual baths, or mikveh, were once extremely important in Jewish communities, they are less so now. They remain, however, compulsory for converts. Men attend mikveh on Fridays and before large

celebrations, women before their wedding, after giving birth and after menstruation. Water is a source of increasing conflict in Jerusalem region, because Israel controls water supplies for both the West Bank and the Jordan River.

**Shinto** is based on the veneration of the *kami*, innumerable deities believed to inhabit nature. Worship of the kami must always begin by a ritual of purification with water. This act restores order and balance between nature, humans and the deities. Waterfalls are considered sacred in Shinto (Smolan and Erwitt, 2006).

The culture of water use is under change, and human behaviour seems to be rapidly altered by commercial advertising, such as the increasing use of personal showers and bathing in certain countries, which is associated with shampoo commercials. Consumer goods marketing has also led to increased energy and resource use.

Culture could also be an avenue for change if a culture of conservation is more widely spread. Changes in ethical value are inherently slow in development and reactive in response, and takes time to construct. This is true for water ethics, especially when people have already used to the approaches of “command and control” and “economic instruments”. Policy options that utilize culture as an agent of change will be discussed in chapter 5.

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12 http://www.worldwaterday.org/page/121
3. Water Ethics

The topic of water ethics is being increasingly discussed as the water crisis grows, and specific policies to ensure access to water are developed. Where water is plentiful, the issues traditionally focused on quality of water, and avoidance of contamination of downstream water resources. However, across the Asia-Pacific region, and the world, water scarcity is having tremendous impacts. Many policies are being developed to ration, conserve and share water resources between communities.

In this chapter, we explore different frameworks for water ethics. This report includes case studies that illustrate use of ethical models and raise ethical issues for use of water, and policies that can be developed. For example, in case study 5, ethical principles concerning water diversion and water usage are tested.

3.1. Ethics and Water

There are several viewpoints of ethics. Descriptive ethics is to describe the view that people have relating to ethical conduct the case studies and observations of people’s behaviour provide us a range of data to consider the world view of different persons. There is a need for more research on the gap between stated attitudes in environmental issues and behavior, however.

From the perspective of prescriptive ethics, ethics is a socially accepted moral standard to define what you can do and what you cannot do (e.g. behavioral ethics) and/or a standard of what harm or pain, such as damage, loss, poverty, thirst, etc., can be inflicted upon other moral agents, including human beings (e.g. consequential ethics). In fact, our whole life as individuals, families and communities is regulated as a matter of course by tacit rules of behaviour and consequences.

The definition of moral agents is important for many theories of ethics. We can see an expanding moral community, from human beings (anthropocentric), to sentient animals (sentience-centric), to living organisms (bio-centric), to the environment (eco-centric). These entities may have their intrinsic rights respected. Actually Aldo Leopold’s (1949) “the Land Ethic” had already expressed this concept, to extend the concept of community to include not only humans but also animals and plants as well as the inanimate components of the environment such as soil, rocks and water. Leopold collectively refers to animals, plants, soil, rocks and water as “land” and states that the land has a “right to continued existence in a natural state”, in at least some places. Given the realities of the global water crisis, we need to adapt acceptable frameworks of environmental ethics to water resources management.

The expansion of “ethical community” from a human dimension to include an ecological dimension increases the difficulty of resolving ethical dilemmas, because the aggravation of the water scarcity issue will increase the conflict between human and ecological concerns. However, Leopold (1949) was enough of a realist to appreciate “The Land Ethic” was a concept before its time, and he compromised by recommending that ethics be considered along with economics and aesthetics.

In fact, today globally we can see some examples where governments and/or land owners

13 Please refer to WG1 report of the EETAP project on “Universalism and Environmental Values.”
have already preserved places where groundwater exists in a natural state, even if our motivation is based on aesthetics. The examples to protect geysers in Yellowstone National Park and to protect even minor springs in many places of the world are a good illustration. We can see other examples such as the creation of marine water reserves to protect biodiversity in oceans or other areas. We can expect with additional technological and engineering advances and with education, our notion of ethics will further evolve to a more ecologically-centred ethic to provide a basis for making management decisions (Anderson, 2007).

3.2. Frameworks for Water Ethics

UNESCO previously examined the question of water ethics through working group meetings organized under the auspices of the World Commission on the Ethics of Science and Technology (COMEST) and the International Hydrology Programme (IHP) in 1998. This led to publication of a series of 14 essays (Priscoli et al., 2004) and the report Best Ethical Practice in Water Use (COMEST, 2004) which also included 5 case studies.

The sub-commission argued that, rather than analyzing once more the ethical issues of water management, it should try to promote best ethical practices. They identified some fundamental principles, as follows:  

1. Human dignity: for there is no life without water and those to whom it is denied are denied life;  
2. Participation: for all individuals, especially the poor, must be involved in water planning and management with gender and poverty issues recognized in fostering this process;  
3. Solidarity: for upstream and downstream interdependence within a watershed continually poses challenges for water management resulting in the need for an integrated water management approach;  
4. Human equality: for all persons ought to be provided with the basic necessities of life on an equitable basis;  
5. Common Good: for water is a common good, and without proper water management human potential and dignity diminishes;  
6. Stewardship: for protection and careful use of water resources is needed for intergenerational and intra-generational equity and promotes the sustainable use of life-enabling ecosystems;  
7. Transparency and universal access to information: for if data is not accessible in a form that can be understood, an opportunity will arise for an interested party to disadvantage others;  
8. Inclusiveness: water management policies must address the interests of all who live in a water catchment area. Minority interests must be protected as well as those of the poor and other disadvantaged sectors. In the past few years the concept of Integrated Water Management (IWRM) has come to the fore and the means to ensure equitable, economically sound and environmentally sustainable management of water resources;

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15 World Commission on the Ethics of Science and Technology (COMEST) and the International Hydrology Programme (IHP), Best Ethical Practice in Water Use, UNESCO: Paris, 2004).
Empowerment: for the requirement to facilitate participation in planning and management means much more than to allow an opportunity for consultation. Best ethical practice will enable stakeholders to influence management.”

There has been considerable reflection on environmental ethics throughout the world. The adoption of the Universal Declaration of Bioethics and Human Rights (UDBHR) by all member countries of UNESCO in 2005 followed a series of consultation meetings. In these meetings a number of agencies and governments called for more formal codifications of environmental ethics principles that have been adopted in international treaties and texts.

The UDBHR provides a universally agreed framework to describe bioethics, which brings together much of the previous scholarship and recommendations in environmental ethics by describing common ethical principles, and providing a framework which could be applied for normative ethical reflection. Although the UDBHR does not elaborate specific ethics for environmental application, it includes a number of consensus statements that can be applied to water ethics. For an ethical analysis of other declarations and UN treaties on the environment please consult the parallel report from the EETAP project Working Group 1 on Universalism and Human Values.

The preamble of the UDBHR states that it is “addressed to States. As appropriate and relevant, it also provides guidance to decisions or practices of individuals, groups, communities, institutions and corporations, public and private”. The stated “aims of this Declaration” in Article 2 include:
“(g) to safeguard and promote the interests of the present and future generations;
(h) to underline the importance of biodiversity and its conservation as a common concern of humankind.”

Principle of human dignity

The UDHR states in Article 3 on “Human dignity and human rights”:
“1. Human dignity, human rights and fundamental freedoms are to be fully respected.
2. The interests and welfare of the individual should have priority over the sole interest of science or society.”

The UDBHR specifically commits states to provide adequate water in Article 14 on “Social responsibility and health”:
“1. The promotion of health and social development for their people is a central purpose of governments that all sectors of society share.
2. Taking into account that the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition, progress in science and technology should advance: ... access to adequate nutrition and water;”

This article is based on the underlying ethical principle of human dignity, a principle which has emerged in many reports on ethics in general, reflected also in statements relating to the use of water. The question of how to balance the interests of individuals and society, and other non-human users of water is a fundamental challenge that is discussed in this report.
The Principle of Equity in Availability and Applicability of Water

Equity in availability and applicability of water is an important ethical issue at all levels, from local community to the global scale. Article 2 of UDBHR cannot be read to mean that one individual can have access to as much water as they like, to the detriment of others. As in UDBHR we read:

“Article 10 – Equality, justice and equity
The fundamental equality of all human beings in dignity and rights is to be respected so that they are treated justly and equitably.”

There is a need for equity of water rights to be promoted. On 11 December, 2008, Mr. Koichiro Matsuura, Director-General of UNESCO, opened a session on the right to water during the 9th World Summit of the Nobel Peace Prize Laureates. Mr. Matsuura underscored that the right to water entitled access to sufficient, safe, acceptable, physically accessible and affordable water enjoyed without discrimination, and equally by women and men. In real life, the equity of water rights could be applied in policy as providing an equal amount of clean water required for human living. Extravagant consumption of water should not be included in this amount, however, there are greater than 10 fold differences in the current average water consumption figures between people living in different countries.

Relationships: Humans live as a member of the environment

We have a deep and eternal relationship with water. The first relationship we have is biological dependence. People may also have socio-biological fondness for water, as with other parts of the environment. It is an evolutionary advantage to like water, and an advantage to value nature. One of the common themes seen in the comments and pictures of nature and life in the International Bioethics Survey conducted in 1993 across a dozen countries in Asia and the Pacific (Macer, 1994) was water, especially rivers and ocean sunsets, with ponds containing birds, fish and other animals. Water has spiritual images of cleansing, purity, being used in most religions, which was also reflected in the survey responses. This data confirms that water is a common image of nature.

The UDBHR Article 17 on “Protection of the environment, the biosphere and biodiversity” specifically illustrates how relationships between different elements of the environment and biosphere, such as human beings, are important in environmental ethics:

“Due regard is to be given to the interconnection between human beings and other forms of life, to the importance of appropriate access and utilization of biological and genetic resources, to traditional knowledge and to the role of human beings in the protection of the environment, the biosphere and biodiversity.”

Although many elements of a water ethic can be expressed as “principles” of water ethics, it does not mean that principalism as an ethical framework is the most appropriate for resolving water-related ethical dilemmas. There is further discussion of anthropocentric versus bio-centric and other world views in accompanying reports. The authors of this report urge policymakers to find appropriate models for the ecological communities that underpin human society in their nations and jurisdictions.

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16 See EETAP Working Group 1 report on Universalism and Human Values.
A Healthy environment

The relationship of ocean science to medical bioethics is suggested by the concept of the "health of the oceans". This phrase was the title of a UNIP Regional Seas report (GESAMP, 1982), produced by the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). The idea of monitoring the health of the oceans was found in several reports in the 1970's, and the concept is now well established. The "normal/natural" state of the ocean is difficult to define scientifically, as it will be changing with time, however, we can certainly find impacts in the ocean’s health and natural state caused by anthropogenic factors. What nations call healthy also is modified with changes in demands for particular resources and services, capital, knowledge, techniques, and political will.

The GESAMP group continues to act as an international group monitoring the health of the oceans, in addition to local groups, and national authorities. It is a constructive way of thinking to use the word health, and we could consider the committee to be among the "Bioethics Committees" of the world in their mandate (Macer, 1994b).

Principle of Vicinity

It is evident that even though someone may have a right to the water in their own country, it is not realistic for a person to get access to the water resources far away from where he/she lives. The principle of vicinity means that when a person needs water, the first choice is to use proximate water resources. This principle gives people who live closer to water the precedence in using it than those who live farther away. But it should be pointed out that this precedence is not a privilege, instead, it is merely due to their favourable situation.

If a person lives closer to water and has the convenience of using it, they also have a special duty to prevent the water from contamination and destruction. There are also special duties on those who use water upstream from others, both for surface and ground water resources.

Principle of Frugality

The principle of frugality means that people in the vicinity of water should not use water exceeding their actual needs. People should only use the amount for basic living needs, for comfort and for maintaining the local ecosystem, so that water that is not used can be used for the communities in the other places lacking water, and kept for future generations. To balance water utilization, the government may develop policy to adjust the levels between the places with water surplus and those with deficiency.

Principle of Mandatory Application of Quantity and Quality Measures

Quantitative and qualitative assessment of the water resources demands, supplies and allocation is both a scientific task and an ethical task. Accurate, reliable and updated data on water bodies will allow us to monitor the surveillance status of all water bodies in order to define the long term strategic policy to achieve or sustain desired status of water condition that supports healthy environment. And to provide operational response or intervene to the negative trends and changes, whenever pollution or other emerging problems. The quantitative status of ground water may have an impact on the ecological quality of surface
waters and terrestrial ecosystems associated with that groundwater body. Therefore, the monitoring and controlling the water quantity, to ensure the balance between the extraction and recharge of groundwater, is important and complementary in securing the water quality. This principle also requires a neutral interpretation of the water status reports and its availability and accessibility to the public. Measures, standards and indicators should be established not only for the objectives of human health but also to protect terrestrial ecosystems, wetlands and their habitats and species.

**Principle of Transaction**

This principle means that the saved and surplus water from the allocated amount should be traded as a commodity in the water market. There are models where special kinds of water, such as spring and mineral water, are excluded from the basic amount for living and are often sold for commercial uses.

**Principle of User Pays**

User pays is an important principle in modern water ethics when water is shifting from a common property or good to a privatized resource. As users of nature, humans should pay a royalty/fee for using a natural resources on the grounds that it is a limited resource and belongs to nobody in particular but to the public, state, international community and so on, as appropriate. If someone is using another locality’s resources, compensation must be paid to the people there, who have degraded their life because of resources transferred away from them.

For the purpose of sustainable and rational utilization of scarce water resources and, to encourage environmentally friendly attitudes, relevant authorities must conduct incentive measures, including water pricing policy. While setting the price, operational costs for the water service and the resource costs may both be recovered (full cost recovery). However, in the European Water Directives, it was decided not to support full cost recovery. Amongst the factors behind that decision is the undermining of a human right to water. In the meantime, the water pricing policy should ensure equitable and affordable access to the safe drinking water, as a basic human right.

**Principle of Polluter Pays**

An application of this principle has been gradually extended from its initial purpose to

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17 This is still very controversial. The common law system is trying to “separate” water from the land so to secure the public intervention. Such proponents are successful due to the practice of “industrial agriculture”, profitable businesses support high monetary income via water trade and this is true for North America and the Western Europe (Spain, France), but has failed in Chile and Argentina (according to FAO and World Bank). In Roman-German legal systems, mineral resources are still public property and with “smallholder farming”, “groundwater based pastoralism” or “arid agriculture” (FAO) that are heavily dependent on aquifers across arid/semi-arid areas in Central and Eastern Asia, it is very controversial. It is also not a case for rainfed agriculture like in the Mekong basin plus Bangladesh, South-Eastern parts of India and Southern China, while in other parts of this region rural livelihood directly depends on water.
mitigate environmental damages as a preventive tool. From its initial purpose to mitigate environmental damages by making the polluter pay, application of this principle has gradually extended to cover the costs of pollution prevention as well. From cost benefit analyses, expenses that water polluter’s service operators must pay to mitigate the pollution are often greater than benefits they derive from the polluting activity. Therefore, the polluter pays principle is a preventive tool, encouraging investment in facilities and measures that prevent, control and monitor pollution.

**Principle of Participation**

Public participation in water resources management is also important so that the interests of all groups, especially the poor and under-represented groups, can be fully represented. Through education, open publication of water data, community hearings, and internet fora and discussions etc., individuals and groups can be involved in water using and managing processes and present their needs and concerns.  

**Principle of Equitable and Reasonable Utilisation**

This customary principle of public international law on shared waters is based on the doctrine of limited territorial sovereignty, recognizing the community of interest of riparian states in a navigable river and “... becomes the basis of a common legal right, the essential features of which are the perfect equality of all riparian States in the use of the whole course of the river and the exclusion of any preferential privilege of any one riparian State in relation to the others ”. This principle was recognized and endorsed in two major normative documents on shared waters, the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention 1992) and the UN Convention on the Law of the Non-navigational Uses of International Watercourses (1997).

The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes incorporates the right of equitable use of international watercourses with accountability via consideration of inter and intra generational equity. The UN 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses (known

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18 We refer readers to the EETAP WG5 on community engagement.
20 UNECE **Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Article 2 (c):** “The Parties shall, in particular, take all appropriate measures [...] to ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact”. Article 5 (c): “In taking the measures referred to in paragraphs 1 and 2 of this article, the Parties shall be guided by the following principles: Water resources shall be managed so that the needs of the present generation are met without compromising the ability of future generations to meet their own needs”. [http://www.unece.org/env/water/pdf/watercon.pdf](http://www.unece.org/env/water/pdf/watercon.pdf)
as New York Convention\textsuperscript{21} set ‘equitable and reasonable utilization and participation’ as a general principle to be applied in non navigational use of international watercourses, strongly emphasizing that mutual cooperation and participation among riparian states is a duty, which should be based on “sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of an international watercourse” (Article 8.1). In determining what is a reasonable and equitable manner, the UN Convention provides a list of ‘factors\textsuperscript{22}’ that must be considered and “the weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole” (Article 6.3).

However, in case of conflicts between different factors and the “absence of agreement or custom to the contrary, no use of an international watercourse enjoys inherent priority over other uses” (Article 10.1) with due regard of vital human needs (Article 10.2).

### 3.3 Future Work on Water Ethics

There is a growing amount of work on water ethics, and more can be developed. This report expects to stimulate these debates and there are a number of discussions. For example, Edward Spence brought forward a meta-ethical framework. An appropriate meta-ethical framework to apply to the analysis of water ethics is based on the ethical theory of the American philosopher Alan Gewirth (1978; 1996). Gewirth’s ethical theory, based on the supreme principle of morality, the Principle of Generic Consistency (PGC), shows that by

\textsuperscript{21} The UN 1997 Convention on the Law of the Non-Navigational Uses of International Watercourses, Article 5.1: “Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal and sustainable utilization thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse”.

Article 5.2: “Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present Convention”.


\textsuperscript{22} Article 6: “Factors relevant to equitable and reasonable utilization”:

(a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;
(b) The social and economic needs of the watercourse States concerned;
(c) The population dependent on the watercourse in each watercourse State;
(d) The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;
(e) Existing and potential uses of the watercourse;
(f) Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;
(g) The availability of alternatives, of comparable value, to a particular planned or existing use.
virtue of being purposive agents (sufficient condition) we have prima-facie universal rights to freedom and well-being and those rights, being universal must be respected by everyone. Because of their universality those rights are global. Moreover, those rights can be extended to include animals and the natural environment generally, and in a word, the whole ecosphere (Spence, 2006).

Given how essential and indispensable water is to the basic well-being of everyone on earth, humans, animals and the natural environment generally, it follows that access and use of water itself is a basic universal moral right. The distribution and of water among its users is therefore an important and crucial universal ethical issue. The distribution of water must, all things being equal, be made on the basis of an equitable division of water resources among all its relevant users. However, conflicts in the division of water resources will inevitably arise among the competing users. Those conflicts must be resolved within the relevant and particular contexts of sustainability, based on the basic principle that the rights of those for whom water is a matter of sustaining life itself (a primary right), as contrasted, for example, to sustaining a level of profitability for some industries (a secondary right), must be given priority.
4. Existing Problems in Current Water Management – the Need for Water Ethics

4.1 Existing Problems in Current Water Management Practices

In the book “Blue Planet Run” by Rick Smolan and Jennifer Erwitt (2006), the following facts and numbers have been listed: 1.1 billion people worldwide – 1 in every 6 – do not have access to clean water; 1.8 million children die every year from waterborne diseases – one every 15 seconds; 40 billion hours have been spent each year in Africa due to the need to collect and haul water; 5.3 billion – two-thirds of the world’s population – will suffer from water shortages by 2025.

In terms of the Asia and the Pacific region, the situation also needs improving. Asia often seems to be a green place, with heavy seasonal monsoons, tropical forests and lush rice fields. Although the situation is not as dire as that in Africa with its massive water shortages, more than 100 million people in South East Asia and the Pacific lack access to safe water and 185 million are without access to safe sanitation. As a result, an estimated 80,000 children die in this region each year from diarrhea caused by drinking dirty water or ingesting toilet germs. The Asian Development Bank said in a report entitled “Asian Water Development Outlook”, “If the present unsatisfactory trends continue, in one or two decades, Asian developing countries are likely to face and cope with a crisis on water quality management that is unprecedented in human history.”

The reasons behind the water crisis are various: climate change, rapid industrialisation and urbanisation, continuing population growth, and mismanagement of water resources. The Asian Development Bank emphasised that mismanagement of water resources would be one of the most important reasons for the “unprecedented” water crisis in Asian developing countries. Future water crises will not come because of actual physical scarcity of water, as many predict at present, instead, it would likely be sparked by continuing neglect of proper wastewater management practices. Water resource management can be defined as the implementation of best practices for effective quantitative and qualitative planning, development, distribution and utilisation of water. These management practices should ensure a long-term stable and flexible water supply capacity to meet multi-purpose water utilisation, at the same time keep a stable relationship between water using practices and their associated environmental consequences. However, water resource management problems can be seen at every stage of the development, utilisation and management of water resources.

(1) Physical Problems

Physical problems still exist in Asia and the Pacific region, for example, poorly developed water supply and wastewater treatment facilities, and incomplete water metering/monitoring systems.

(2) Water Pricing Problems

Low water prices are one of the leading factors contributing to excessive water use in agriculture. The methods of determining the water price should be sufficient to meet operation and maintenance costs. Take China as an example, water pricing is generally based on irrigated land area or only based on the electricity used. The water prices applied
for industrial and domestic uses do not reflect the actual cost of water either.

(3) Organisational Problems

Most of the water conflicts are caused by organisational problems. “Integrated Water Resources Management” has not been fully implemented in most of Asia and the Pacific regions. In the case study 2 “A Brief Introduction to the Trans-jurisdictional Water Quality Issues in China”, the overlapped and distributed institutional organisations will be introduced.

4.2. Pollution

Human activity is the main cause of ecosystem changes in the world. We can see the effects of human activity everywhere in the world, from atmosphere to oceans, from poles to the tropics and from the depths of the oceans to the highest mountains. The concept of stewardship is required to maintain a sustainable way of life, and a healthy world. Environmental problems may be able to be traced back to the beginning of civilization, but are getting worse with the global scale of air and water pollution, the introduction of new chemicals, and the still growing human population.

Much damage is unintended and unforeseen, such as the acidification of lakes in Scandinavia and Canada from the acid rain from the burning of carbon fuels. Restrictions on the release of sulfur and nitrous oxides have reduced the level of these acid residues, showing that pollution can be controlled. While sulfur dioxide emissions have fallen, the acidity of rain has actually remained high in polluted areas, due to parallel reduction in the basic cations (contributed by particulate matter) in the atmosphere that neutralize acid rain (HEDIN et al., 1994). There still needs to be further reduction in pollution if acid rain is to be avoided. We can expect this issue to continue as more coal-based energy plants are used in countries with growing energy needs, and with concerns about other sources of energy and national energy security.

Pollution could be defined in many ways. One definition is that pollution is the appearance of some environmental quality for which the exposed community has inadequate information and is thus incapable of an appropriate response (Cairns and Lanza, 1972). Pollution can also be defined as the introduction by humans, directly or indirectly, of substances or energy into the environment resulting in deleterious effects as harm to living resources, hazards to human health, or hindrance to particular activities. The oldest method of pollution "control" that has been used is the principle of infinite dilution of wastes. Water is historically one of the substances in which wastes are diluted, perhaps why it has the associated spiritual meaning of holiness and purity. Increased industrialisation usually means increased production of wastes and potential pollutants. In the ocean, substances including carbon dioxide, cadmium, arsenic, lead and mercury are all disposed of in greater quantities than the natural fluxes can cope with. Under conditions of stress the species diversity of communities is greatly reduced, and the result is that the system becomes much less stable (Odum, 1971). The most effective control is to eliminate production of the pollution, at least to decrease the levels to what natural cycles can cope with. If it is not possible, treatment of the pollutants and/or the consequences is necessary in many cases before substances suitable for recycling or dilution can be released.
Many pollutants threaten water supplies, but the most widespread, especially in underdeveloped countries, is the discharge of raw sewage into natural waters; this method of sewage disposal is the most common method in underdeveloped countries, but also is prevalent in quasi-developed countries. Sewage, sludge, garbage and even toxic pollutants are all dumped into the water. Treated sewage forms sludge, which may be placed in landfills, spread out on land, incinerated or dumped at sea.\(^{23}\) In addition to sewage, nonpoint source pollution such as agricultural runoff is a significant source of pollution in some parts of the world, along with urban storm water runoff and chemical wastes dumped by industries. Wastes include municipal sewage, animal wastes and agricultural fertilizer runoff. To solve this problem these nutrients must be removed before such wastes are released into the water. In 1970 the animal population in the USA was estimated to be 564 million head, which produce the waste equivalent to 2 billion people. The animals in intensive animal production facilities are also associated with high energy use.\(^{24}\) Water tends to be the ultimate sump for waste, and we are dependent upon the natural ability of ecosystems to cleanse waste and produce clean water. It is ironic that the economic benefits of natural actions are usually of no value in economic equations.

Eutrophication occurs in waters that have enriched nutrient content which support excessive algal photosynthesis. Increased algae growth results in oxygen depleted water which is detrimental to the health of fish. Increased temperature due to climate change and waste water from industry or cooling water from energy power plants, lowers the oxygen concentration of water, which makes the ecosystem more susceptible to stress.

The effects of pollution can be immediate, such as the sudden death of a large number of fish, or more prolonged such as defective development and reproduction. PCBs were widely used in many industries before their toxicity was understood, particularly as insulators in electricity systems. The level of PCBs in some marine animals exceeds the health standards set by some national authorities, but there are no known cases of human sickness from the consumption of animals and fish with these substances. However, seals may have suffered reproductive damage as a consequence of the level of PCBs (GESAMP, 1982, 1990).

### 4.3 Governance models

Historically, water resources management was based on a “command and control” approach. More recently, “economic instruments” have been implemented. Water ethics is an important, but frequently ignored element in regulation. Equity in availability and applicability of water is the important ethical issue at all levels, from local community to the global scale. According to Harremoes (1996, 1997), water resources management has developed to encompass more instruments and more philosophical issues, as illustrated by the following list:

- Command and control: laws, directives, standards, norms and codes
- Economic instruments: taxes, levies, subsidies
- Consensual approach: hearings, consensus conferences, stakeholder participation
- Ethical approaches: ethics, morals, attitudes

\(^{23}\) Groundwater in Urban Development

\(^{24}\) See EETAP WG13 report.
The "command and control" approach is an elitist, centralised system, deciding on the "command" as a top-down approach to management. That may work for big water projects and point sources of pollution, but it works poorly for the distributed water handling in agriculture and industry, and domestically. It is difficult to control diffuse sources, source abatement, cleaner production and cleaner products by centralised means.

That is where economic incentives have come into the picture. Environmental economics has become a discipline in its own right. However, for some values that cannot be measured by economic levers and numbered by price, this method loses its advantage. In fact, we all affect the environment by our daily behaviour. We have reached the stage in environmental abatement where the success of policies depends on daily decisions and activities of the individual, local communities and companies as much as on centralized rules and regulations. The ethical values and the associated attitude and behaviour are the foundation of a society that makes it work. Such values have to be addressed "at source", by bottom-up approaches. Development of the ethical value of environment to the consumer, to public utilities and to industry has the potential as a far more effective, cheaper and acceptable means of "regulation", as a supplement to a society. The difficulty is time. The driving forces and pressures on the environment change rapidly, while changes to ethical values are inherently slow in development and reactive in response, as opposed to a needed proactive paradigm. "Over-regulation" is an understandable response to rapidly developing conflicts and crises, but the long-term aspects of ethics and values should not be disregarded.

As we see the rise of mega-cities, some municipalities have more persons than entire countries. These cities tend to be able to buy water from the economically poorer rural areas, while also having the advantages of economy of scale to enhance water quality compared to smaller cities, leading to gaps in the water quality and quantity people can access.

4.4 Access rights to water in practice

Thomas R. Odhiambo, past president of the African Academy of Sciences, said that “The art and practice of equitable distribution of and access to fresh water for all people in the 21st century, as a fundamental human right and international obligation, is the mother of all ethical questions of all transboundary natural resources of a finite nature” (Krimsky, 2005). Water rights have been discussed and assigned for millennia under different cultures (Barraque, 2004). The rights usually reflected the ethics of the day, which at times was inconsistent with our modern norms of ethics.

The proclamation of the 1977 UN Water Conference also mentioned that “All peoples… have the right to have access to drinking water in quantities and of a quality equal to their basic needs.” Those reflect a human-centric viewpoint, i.e., anthropocentric ethics. The important ethical issues within the anthropocentric ethical framework are the international water dilemmas and potential conflicts associated with water rights and duties.

Firstly, inside nations there are growing disputes. By installing metering facilities and measuring the supplied/used water amounts, we can record and track water utilization, which is a prerequisite for scientific and ethical management of finite water resources. For example, the Yellow River Committee is a Chinese governmental department that is in charge of the quantification and allocation of the Yellow River’s water for the adjacent provinces along it. This can check environmental “health” for better policy responses in addition to the safety
and sanitation of the drinking water. Water metering is a system to collect service fees for the used water or to control individual behavior to minimize water use, while knowledge of actual water resource will provide us a clear indication of socio-economic value of water.

In many developing countries the extraction of groundwater is as if it is part of the land and any land owner can extract groundwater inside his/her plot without permits or hindrances for domestic use, irrigation or for selling the drinking water. The development of this type of unregulated extraction of common resources must be discussed under ethical use of public property even though it is within one's own plot of land/town/division and/or country. The groundwater aquifers often transcend the political boundaries of the countries and it is in fact transboundary water in many areas.

The classical issues in water access rights are related to the right to withdraw groundwater, the conflict among users at the upstream and downstream of rivers, the potential impact of mega water diversion projects, and transboundary water conflicts. In 1966, the International Law Association approved a draft set of rules regarding equitable use of international river waters (Starke, 1987; Schachter, 1977). Of the various factors listed, the following points are mentioned (Islam, 2008):

1. Water utilisation of the river basin at present and in the past has to be considered;
2. The extent to which the population of each basin state is dependent on the river water has to be taken into account;
3. Research on the comparative costs of alternative means to meet the economic and social needs of the people of the basin states should be carried out;
4. Care must be taken to avoid unnecessary wastage when utilising river water;
5. Availability of other resources has to be considered;
6. The extent to which compensating one or more of the co-basin states for adjusting conflicting uses has to be evaluated;
7. The extent to which the necessities of a riparian state can be met without causing substantial harm to a co-basin state has to be taken into consideration (Schachter, 1977).

During the late 19th century, the Harmone Doctrine, according to which a state has the absolute right to use the water of the rivers flowing through its territory as it wishes, without considering its effects on other states was quite influential. However, this doctrine has never been followed. Rather, there are various examples of peaceful water sharing between two or more riparian states through which a river flows. Below, we point out some treaties of this kind.

In 1909 the Boundary Water Treaty between the US and Canada was established. Article Two of the treaty reserved for each side unrestricted territorial control over the boundary water within their territory and available legal remedies. However, under the 1961 Columbia River Treaty, both the US and Canada adhered to the principle of shared enjoyment and optimum utilisation of common waters through international cooperation. They have jointly undertaken comprehensive and integrated regional planning for the development of the Columbia watershed water resources (The UN L. Series, 1963).

Even in extreme cases of common water disputes, accountability of claimants and recognition of mutual rights are apparent. An example is the sharing of the Jordan River water between Jordan and Israel. Both parties had either implemented or taken initiatives to utilise the Jordan waters unilaterally. Although the initial efforts for negotiation by an envoy of
President Eisenhower’s (Special Ambassador Eric Jonston) had failed due to political reasons, eventually both parties came to recognize that each had rights to a reasonable share of the Jordan River water and that neither party should unilaterally interfere with its counterpart’s share (Islam, 2008).

Through the treaty between Egypt and the Sudan (1926), Egypt got a reasonable share of the Nile water by cooperating in building a reservoir at the upstream, within the territory of Sudan. This case is an example, proving that “mutual confidence and cooperation in all matters concerning the river and its waters” are of much greater importance than that of arbitral tribunals, legal rules and expert commissions joined together (Smith, 1931).

On the question of the use of international drainage basin water, there exists a persistent pattern of state practice and community expectations of shared competence and control. This pattern is reflected in the recurrence of identical provisions in a significant number of treaty practices of basin states all over the world. These treaties specify, in one way or other, the freedom of action of the signatory basin states.

The multiplicity of these treaties is the clear evidence that basin states have felt an obligation to work on the basis of mutuality and cooperation in the use of their common waters. The number of basin states which are parties to these treaties, their spread both over time and geography, and the fact that, “...in these treaties similar problems are resolved in similar ways, make of these treaties and negotiations persuasive evidence of law creating international practice” (Islam, 1987). The irrefutable exercise of national sovereignty over the Teesta River between India and Bangladesh for example would appear to be contradictory and a deviation from the existing international practice.

China’s current mega South-to-North Water Diversion Project will be discussed in the fourth case study and the ethical considerations will then be illustrated in the case study 5. In some sense it is politically easier because the diversions lie within one country, but certainly bring many communities into potential conflict. In South East Asia the Mekong River Basin is the site of some ongoing international strategies for water management, given that the river is being used for hydroelectricity production and agricultural use. In cases such as the Mekong, a number of different services are in competition with each other such as electricity production, irrigation, flood production, fisheries and industrial uses (Resurreccion et al., 2008).

The bioethical issue is not only providing access to water, but also we should try to avoid harm caused by pollution or reduced access to water. We need to attempt to understand the consequences of direct and indirect effects of our action in a complex ecosystem.
5. Policy options and Construction of Practical Water Ethics

From the above review of ethics and science of water use, we can conclude that while water ethics is an important basis for a growing range of policy approaches, water ethics is a frequently ignored element in regulation. The reason is that changes in ethics of motivation, improved conservation behaviour and consequences are generally slow, but still important as a prerequisite for making the latter work. The construction of practical water ethics and lifestyle change is a long-term project, which needs sustained efforts at all levels, from local community to the global scale.

Assessment of Water Quantity and Quality

A prerequisite for ethical acceptable water resources utilisation and management is to objectively assess the total available water amount. The available water here means the water with certain quality that can be utilised for a certain use. For a long time, people only focused on water quantity but ignored the quality issue. With the aggravation of water contamination and the degradation of water quality, not only “availability” but also “applicability” of water has been emphasized. Various scientific methods are available for water resources assessment, including field survey, remote sensing, numerical models etc. The information from the assessment would provide the basis for the subsequent water resources planning, allocation or even transaction and compensation.

The accounting and audit for water use needs to be transparent and open, and we could suggest people become aware of their “water fingerprint” in the same way as the term “carbon fingerprint” has become popular.

There is an ethical obligation on water providers to ensure adequate water quality. The obligation to protect water from pollution is shared by all who contribute to pollution. Minimal water residue levels are one method to protect water quality, and WHO has set guidelines based on human health. Although one attitude that is displayed by some jurisdictions when faced with challenging standards, is that countries and municipalities can give up on meeting these, standards need to be based on a solid ethical framework for protection of both environment and human health, not only pragmatism.

International agreements already include ethical principles to prevent pollution. Trondalen and Munasinghe (2004) argued that the Polluter Pays Principle, the Precautionary Principle, the Principle of national responsibility for transboundary pollution, and the Principle of institutionalized Environmental Impact Assessment are all embedded in international environmental conventions such as the Basel Convention and the United Nations Framework Convention on Climate Change.

While developing and/or applying certain standards, whatever for the purpose of human health, sanitation or environmental status, we should note that they are defining the mandatory minimum requirements for constituents of water or indicators of water quality. Therefore, standard is the point of departure and its criteria or measurement should not limited by the technical knowledge or specifications. Instead, it should be determined and leaded by the quality values. For example, the Directive 2000/60/EC of the European Parliament and of the Council on “Establishing a framework for Community action in the field of water policy” set the water quality status as a “high, good, moderate, poor or bad”
indicating its essential quality values so that measurements are secondary to the values that the document want to protect and preserve. The International Standards Organization (ISO) has issued a number of international standards related to water quality.\(^{25}\)

**Policies to Overcome Economic Water Scarcity**

Water scarcity can be categorized into economic and physical water scarcity. Economic water scarcity is where human, institutional, and financial capital limit access to water even though water in nature is available to meet local demands. Although physical scarcity of water is challenging to overcome through conservation and water resource management tools, economic policies can be modified to provide water to those who face scarcity despite presence of water resources. One of the contributing factors to provision of water in these areas of the world is privatization of water, which is a controversial policy strategy.

In 1998 at the UNESCO Conference on World Water Resources at the Beginning of the 21\(^{st}\) Century, some participants from Islamic countries rejected economic models of water that

\(^{25}\) Both methods and constituents of water are covered, in the lists available at:
http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_ics_browse.htm?ICS1=13&ICS2=60

Selected examples include:
ISO/CD 9698: Water quality -- Determination of tritium activity concentration -- Liquid scintillation counting method
ISO 10703:2007: Water quality -- Determination of the activity concentration of radionuclides -- Method by high resolution gamma-ray spectrometry
ISO/DIS 10704: Water quality -- Measurement of gross alpha and beta activity concentration in non-saline water -- Thin source deposit method
ISO/DIS 11704: Water quality -- Measurement of gross alpha and beta activity concentration in non-saline water -- Liquid scintillation counting method
ISO/CD 13160: Water quality -- Measurement of strontium 90 and strontium 89
ISO/CD 13161: Water quality -- Measurement of polonium 210 concentration activity in water by alpha spectrometry
ISO/CD 13162: Water quality -- Determination of carbon 14 activity -- Liquid scintillation counting method
ISO 17381:2003: Water quality -- Selection and application of ready-to-use test kit methods in water analysis
were adopted in the 1992 International Conference on Water and the Environment held in Dublin, citing the Koran that characterizes water as a free gift of God. For example in the Dublin conference the fourth guiding principle reads:

“Water has an economic value in all its competing uses and should be recognized as an economic good. Within this principle, it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price.”

Further conferences attempted to resolve this issue, discussing Islamic perspectives, and concluding that the fourth principle was consistent with Islam (Priscollli, et al. 2004). However, there is hot discussion regardless of religion about the privatization of water and its impact on economic scarcity. Policies need to be developed and institutionalized to take account of the ethics of financing models at all levels of water access (Teniere-Buchot, 2004).

**Modeling Method – A Useful Decision Support Tool**

Natural resource planning spans orders of magnitude across spatial as well as temporal scales. Overlaying the natural processes, economic drivers and human demands further challenge the decision making process. Considerations of different management options that account for sustainable energy and water resources can be effectively tested using modeling and simulation. While models can be biased and oversimplify pertinent physics, the development process and the simulation outcome offer quantitative information, enhance insight, educate a broad audience, and reveal unexpected sensitivities or nonlinearity.

Nowadays, water resource models have been used to inform decisions about water supplies, ecological restoration, and water management in complex regional systems. Every single major water resource planning and management activity in the world today, whether focused on flooding problems, reservoir operation, groundwater development, water allocation, or aquatic ecosystem enhancement, includes models. A team at Sandia National Laboratories, USA, has developed models through stakeholder elicitation that can address a wide range of regional-, national-, and international- challenges dealing with integrated resource planning. The third case study for computer-aided, community-based water planning: Gila-San Francisco decision support tool will be introduced to illustrate the application of modeling approach.

**The Role of Experts, Stakeholders and Decision Makers**

In the framework of water ethics construction, decision makers, stakeholders and experts should all take on corresponding responsibilities (Figure 6). This is true for both private and public sector experts.

Experts in the different roles as illustrated in Figure 6, no matter whether natural science or social science, should have stronger environmental concerns due to their deep understanding of the nature and water resources. Therefore, experts should take the responsibility to advocate, educate and propagate ethics, and help the decision makers and public build up the consciousness of protecting the environment (Zheng, 2005). One dilemma is that experts are often highly specialized, and the consequence is a narrow interpretation of

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26 Ocean dumping of sewage sludge is prohibited in the United States by the Marine Protection, Research and Sanctuaries Act (MPRSA).
what the issue is, a specialized terminology and a tacit understanding of concepts, problems and solutions within the expert community (Harremoes, 2001). For integrated water management, interdisciplinary collaboration is needed to bring all elements together. Experts in different water related fields should work jointly and combine social, human sciences with natural sciences during the constructing of water ethics.

All stakeholders play an important role in the construction of the actual water ethics and the ideal water ethics. Especially the major water users, because they use the greatest part will be central to construction of an improved water ethics. If they take their social and environmental responsibility, adopt water saving technologies, recycle water resources, follow and respect natural rules and protect the environment (water resources) self-consciously, then the construction of water ethics will be easier.

Figure 6: Construction of a Framework of Water Ethics (Liu, 2007)

The role of decision makers is essential in the design of water institutions and water policies. Decision makers have the responsibility to combine the ethical institutional considerations into the policy making, and design water institutions which are both economically efficient and compatible with the ethical principles.

The final case study - “water ethics reflections in eucalyptus planting” shows a good example of how scientists, stakeholders and decision makers play their important roles in alleviating water scarcity based on ethical judgment, instead of being driven by economic benefits only.

Education
As Harremos (2001) mentioned, “while the prospects (water ethics) may be grim, the hope may rest with education.” It is a feature of modern society that mass education has become feasible at a rate and to an extent never seen before. The case study 6 - “Teaching Plan on Water Crisis in a High School of China” is introduced in the annex to illustrate how to create awareness and education for young people.

We must really put a concerted effort in including water ethics in water education at all levels. In the traditional water education system, people are usually trained to use science and technology to fully develop and efficiently utilize water resources. However, the key problem concerning the ethics of water management is not just a problem of efficiency, and the ethics of water can never be reduced to certain skills and technologies. The most important thing is to create an equally communicating atmosphere so that all subjects (including nature itself) within the system have chance to express their viewpoints about the reasonable utilization of water.

Professionals such as engineers or scientists who control the great power of knowledge must uphold highest standards of professional ethics as well as general virtue of human beings in order not to increase the risk of the world. As an example given by Liu (2007), “a boy who pisses into the source of drinking water once is not moral even though it is OK from the point view of science and technology, because the amount of his piss is trivial to pollute the water”, the limit of scientism should be broken through during education.

Balancing International Governance with National Sovereignty

For many countries the water is not only an ethical issue but also a political problem. For example, the countries in Central Asia, like Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, have common rivers and great interest in water resources. The system of the fair sharing of water is absent. How should each country make decisions on the energy/resource technologies that they develop and which strategies to follow, given the environmental crisis and the variety of proposed benefits and potential risks of different technologies? As countries in the Asia-Pacific region face mounting external pressures to decide on their energy/resource policy, what are the values and questions that exist inside the region for ethical deliberation over the choices for energy/resources? There can be useful resolution of conflicts between cultures and communities in shared use of common water, such as oceans and rivers, through international commissions, laws and treaties. At the same time nations wish to preserve their sovereignty.

Among the first major international laws protecting the environment is the Law of the Sea, which looks at the problem of protecting the global commons. This shows early recognition of the ethical principle of justice, applied in human responsibility to protect nature and the environment. The Law of the Sea became a forerunner to the more recent global conventions on protection of the ozone layer, biodiversity, and efforts to prevent increases in greenhouse gas emissions which contribute to global warming. While many national laws aim at reducing pollution, and preserving rivers, lakes and marine parks, and some regional blocks such as the European Union impose strict environmental standards, negotiations to apply international standards have been difficult (Islam, 2008).

How can we ethically control overuse of resources? Most maritime nations have declared 200 mile limits within which they claim prior rights to exploit marine resources,
including fish. Therefore national policies are very important, but because most fish, and the water they live in, move over much greater areas, international fishing strategies are necessary. One way is to enact quotas, a given number of fish of each species that should be caught. Quotas were introduced to North Atlantic fishing since 1970.

Global influences are being recognized which require global bioethics. For example, natural variations in fish population are primarily related to the population of plankton on which they feed (and human action). The algal productivity varies greatly, with winds, sea currents, and climate - which itself affects the ocean currents. Increased fish catches of Atlantic cod, from the fifteenth century, have been associated with warmer climatic periods. Temperature also affects biological organization of the ecosystem, and global warming can be expected to change not only these patterns but rainfall, affecting the land too. Unintentionally humans have begun global eco-engineering, and now considering intentional changes to combat these. For example, there have been experiments since the 1990s to add iron into the ocean to attempt to fertilize phytoplankton production.
6. Conclusion

There is an accepted international ethical norm that human beings are entitled to access to water as a human right. Equity in availability and applicability of water is an important ethical issue, that has significant policy implications. Development of water ethics is an important supplement to the traditional “command and control” and “economic instruments” that are common in modern water resource management. There are several key principles listed in this report that can be applied in different cultures and circumstances. The principles of equity, vicinity, frugality, quantification, transaction, users pay and participation are guidelines for water ethics and construction of policy.

The world view varies from anthropocentric to eco-centric viewpoints across countries in Asia and the Pacific. Aggravation of water scarcity issues will increase the conflicts between human and the ecological concerns if an eco-centric view is adopted, however without such a view humankind will lose even more biodiversity and environment. There are existing precedents for international water-sharing including with primarily non-human environmental systems, and for protection of environmental resources, however, they need further development.

Conducting objective assessment of water resources and implementing modeling tools will provide a scientific basis for construction of practical water ethics. Experts, stakeholders and decision makers all should play important roles in constructing water ethics. Education should be conducted, starting from young people, and including professionals in every sphere of decision-making.
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Annex - Case Studies

Six case studies conducted by the members of the WG14 have been used to illustrate ethical considerations in various fields. These include examples from aquaculture, water diversion, trans-jurisdictional water quality issues, modeling studies and education. These case studies provide real-world examples and good overviews of water challenges confronting human beings.

Case Study 1 – The Need for a More Efficient Aquaculture Industry
(Keisuke Tachiyama, Japan)

Introduction

The technological revolution has supported the human population in terms of food production even as it continued to grow at an exponential rate. This seems to prove the early prediction made by British political scientist, Sir Thomas Richard Malthus as being false. His famous quote is still used by geographers all around the world: “Food production will only grow at a numerical pace, while the human population continues to grow at an exponential rate.” However, when one studies the current state of food production and the energy usage associated with it, the scenario predicted by Sir Thomas Richard Malthus seems to be closer to becoming a reality.

The aim of this paper is to illustrate how the current state of aquaculture came to be, using the collapse of the natural stocks of Atlantic cod to argue why aquaculture is a necessary alternative in terms of supplying a stable stock on the market. At the same time, some of the details of the sushi boom and how the rise of Japan (economically) has started a trend of seafood consumption throughout the world will be discussed. Then how the current state of aquaculture is aimed at producing high-value products (shrimp, salmon, and tuna) and how that is producing many unfavorable environmental and sociological effects will be illustrated. At the end of the paper, the essay would introduce a form of sustainable aquaculture (carp and oysters) and argue that we have a need to diversify our diets so we can protect marine ecosystems and protect fishmeal resources for future usage.

Seafood growth perspectives

Currently, Asia is the greatest consumer and producer of all seafood products; this number is expected to continue to rise. According to the data released in the year 2000, the Tsukiji market in Tokyo continues to be the basis for determining international seafood prices (although this might soon be surpassed by the seafood market in Shanghai), trading a total of $6 billion USD worth of seafood on an annual basis. For comparison, the largest seafood market in the United States; the Fulton Fish Market in New York only trades $1 billion USD on an annual basis, which shows the immense influence held by the Tsukiji market.

In recent years, the influence that Japan once exerted on seafood markets is dwindling as other markets in Asia gain more influence. Currently, large amounts of seafood imports can be seen in ports of Pusan, Shanghai, and Taipei. They are growing and are competing against each other to surpass the insurmountable power currently held by the Tsukiji market.
How Aquaculture evolved

Aquaculture has evolved greatly in the past three decades. However, it is worth noting that the beginnings of aquaculture can be traced back to more than 3000 years ago. In ancient China, carp were kept in artificial ponds and were later consumed by the residents of the local villages, resembling a subsistence-type system; leading to the conclusion that it was sustainable. For much of its history, aquaculture remained this way. Even after globalization started changing how business was conducted, aquaculture continued to be a subsistence system that primarily fed the people in the villages of the developing world.[10]

During the same time period, the natural fisheries around the world also supplied its catch to the people in the developing world while the people in the developed world primarily consumed poultry products.[1]. However, this drastically changed in the last three decades of the 20th century, primarily due to three factors: the rise of the sushi boom and the health consciousness that was born as a result of the Bovine Spongiform Encephalopathy (BSE or known as the Mad Cow Disease), and the advancements in refrigeration technology that allowed seafood to travel greater distances without spoiling.[7] These factors completely changed the flow of how the seafood market conducted business. From this point onwards, both natural caught/cultured seafood products were produced in the less developed world, only to be consumed by the people of the developed world.[5]. The diets of seafood consumption also shifted from marine organisms that were placed low on the food chain (carp) to one that were high on the food chain (shrimp, salmon, and tuna)

Without going too deeply into this issue, it is worth keeping in mind that the one main factor debated by several oceanographers that was responsible for the rapid rise of the popularity of seafood was the sushi boom that started towards the end of the 20th century.[1]. There have been various discussions of the way Eastern and Western cultures view cultural and economic exchanges.[10]. There have been many studies of the relationships between Japan and the United States since the 1960s. The United States was the key player in the global economy and Japan was just starting to gain economic wealth. But as the 1970s progressed and as we entered the 1980s, Japan experienced the economic bubble and became the 2nd largest economy in the world.

Rise of the Sushi Boom/Aquaculture

During this time, large amounts of Japanese Foreign Direct Investment (FDI) started flowing into the United States, changing the previous flow of FDI (from the United States to Japan). Japanese sushi parlors started opening up in various areas of Manhattan and onto other North American cities. Japanese food was advertised in various magazines and television channels as being a healthy alternative to consuming meat products. Coincidentally at roughly the same time, refrigeration and freezing technologies improved; thus making it possible for seafood to be shipped from various ports around the world (primarily in developing countries) to countries that were experiencing the sushi boom.

In addition, consumers in the United States also experienced a very interesting phenomenon at this time. Shrimp/Prawn products were a popular food product amongst many North American consumers even before the sushi boom.[1]. However, due to refrigeration technology and its limited biomass, the food product was considered a cuisine that could only be enjoyed along the banks along the Mississippi River. Prices also remained relatively high,
reflecting its limited biomass. However, demand soon began to surge with the introduction of the sushi boom and new refrigeration technologies. Frozen shrimp/prawn products soon began to be sold in super markets across the entire North American continent and the prices soon started to drop as more and more of the natural stocks were extracted.

However due to the natural variability of the natural stock, the governments of the major consuming nations looked for an alternative. These were the beginnings of large scale shrimp farming in various areas of Latin America and Southeast Asia. The government of the developed countries specifically allocated FDI through various ODA organizations such as the World Bank and International Monetary Fund and promoted shrimp aquaculture to developing countries as a way of earning foreign currency.

Due to these efforts that were enacted by various ODAs in the developing world, we (the citizens of the developed world) were and still are able to consume cultured shrimp/prawn products for a relatively low price. But the story of the ecological disasters that the shrimp farming industry has created is cited in many literature pieces. For instance, we have destroyed important mangrove forests that act as buffer zones during storm surges, and are changing the diet of the Southeast Asian people in that we are forcing these people to transform rice paddies into aquaculture sites, toxic materials used for shrimp aquaculture are polluting coastal areas, etc. In addition shrimp epidemics are frequently emerging in many Southeast Asian coastal areas[5]. When this happens, there is no choice for the farmers but to kill off their entire stock and drain the water supplies in the pen to the adjacent coastal areas, leading to further pollution.

However, we simply cannot place the blame on the farmers in the developing countries that are producing cultured products. Some economists suggest that it is ultimately the consumers of the developed world who are responsible for this rapid change in aquaculture production systems. We have demanded products with better quality, greater variety (shipped from further areas), that are available all year round, for a cheaper price. Unfortunately even after economists/oceanographers started stating these facts in their literature, aquaculture has continued to grow in importance over recent decades.

**Why over-reliance on natural stocks is so dangerous?**

Perhaps the natural stocks of Atlantic Cod in Maritime Canada were the worst seafood disaster in recent history. This natural fishery was created in the late 1970s in Eastern Canada when the government decided to open up its coastal areas to earn foreign currency [6]. This decision came from the fact that cod were widely consumed on the other side of the Atlantic (Norway and Portugal). Since the local residents of Atlantic Canada consumed a minimal amount and had such a large surplus; the government decided to exploit it and strengthen the economy of Eastern Canada. For the first few years after the fisheries opened up, the economy prospered, creating many new jobs for the local residents. However, the size of the operation was extremely unsustainable from the beginning. More than 300,000-800,000 tons of Atlantic Cod were caught on an annual basis and were processed at local plants. This created more than 40,000 jobs and the once baron cities of Atlantic Canada regained its vibrant atmosphere. However, the local fishermen continued to warn the government to implement restrictions on the catches since the local fishermen felt the effects by seeing fewer fish in coastal areas in the course of their daily operations. Marine biologists often cite this
ignorance by the Canadian government as being responsible for the tragedy that unfolded in the next few years. Soon catches started declining and the multinational corporations that were associated with cod operations started suggesting that the Canadian government implement some kind of restriction in order to protect the fisheries. However, when restrictions were finally implemented by the government on July 2nd, 1992, it was already too late. The stocks had diminished due to over-fishing and the natural habitat of the coast off Maritime Canada had been destroyed. The catches for 1992 were a mere 17,500 tons, opposed to 800,000 tons at its peak [6].

It is examples of fishery collapses such as this that worried governments throughout the world. Once thought to be an infinite resource, was exploited within two decades and still only marginally recovered in 2008. However, today the demand for cod in the European nations is being satisfied by aquaculture operations that are practiced off the coast of the Scandinavian Peninsula. Furthermore, the industry has expanded itself and today, large amounts of carp, catfish, clams, tilapia, milkfish, oysters, salmon and shrimp are farmed [11]. The argument of the governments of the developed country is that, aquaculture is a vital way of ensuring that many seafood stocks are supplied throughout the year since some migratory fish stocks have seasonal fluctuations of abundance and absence.

**Effects of Aquaculture on natural stocks**

The human induced ecosystem disasters have already been discussed in the section of farmed shrimp, but there are other unfavorable effects that aquaculture is known to potentially produce. Before discussing those details in detail, statistics show that roughly 25% of all seafood products around the world are cultured products. But as we progress more into the 21st century, that number is expected to rise to 75% by 2100 [11]. These statistics point in a direction that we have to be concerned about. The composition of the fish meal is as follows; body parts of the fish and fish oil which are extracted from natural stocks of small fish such as Peruvian anchoveta, Icelandic herring, men-haden from the Gulf of Mexico, Norwegian capelin, and sand eels from the North Sea. From the list above, one can visualize that fishmeal is produced in: Peru, Chile, Iceland, and Denmark [11]. These countries currently produce so much excess fishmeal so that the surplus is used in other food producing sectors such as the poultry industry. But this is made possible because only 25% of seafood around the world is cultured; and currently, there is a large surplus of fishmeal that is extracted from our oceans. However, if this number were to go up to 75% (expected to occur by 2100), then large amounts of fishmeal would be needed and the natural stocks might not be sufficient to sustain it. Thus this could point in the direction that we would have to culture the fish used for fishmeal in the near future for the sole purpose of growing cultured fish.

If this happens, the meal that is currently used in the aquaculture industry could suffer crucially because at some point, the surplus of fish feed will be used up. As there is more demand for fish-meal, we can expect prices to rise, and this would be reflected directly to consumers. Marine biologists/oceanographers are currently warning the multinational corporations and the governments of the developed countries who are intensifying their operations, but the situation remains unresolved. This is because the aquaculture market is driven by market forces, short-term profits, and export earnings for the developing countries [11]. This means that unless there is a sudden drop in demand for cultured products,
aquaculture will continue to gain its importance. At the same time, the diets of Asian people are also currently shifting to high value fish consumption. Furthermore, what is alarming is that currently many countries in Asia are gaining economic strength (such as India and China). As discussed earlier, many ponds in China currently rely on a subsistence system, culturing fish such as carp which feed low on the ecologic food chain and are grown in ponds for consumption by the local people.\[11\]

Yet, if the economy of China continues to grow at its current rate, the middle class in the country would expand and they would start favoring carnivorous species of seafood such as shrimp, salmon, or tuna. If this becomes a reality, the sustainable polyculture system practiced in local villages in China (where many species exist together to maintain better water qualities) would fall apart and production in total, has the risk of decreasing dramatically. As the farmers gained economic prosperity, they gradually shifted their operations from being a natural type (carp eating feeding on the natural plants in the pond to one that uses fishmeal and soya beans for feed). Articles written by Dr. Tibbetts shows that the current Chinese aquaculture market price trend resembles the prices of soya beans showing how correlated they have become. Currently, China is the largest aquaculture producing nation in the world, producing two thirds of total global consumption.\[11\]

Just to get an idea on how inefficient the practice of aquaculture is in other countries, we can view some of the numbers that have been cited. The data presented in an article by Rosamond et al. is alarming. According to his research, marine shrimp and salmon individually use more than 2000 wild-fish as fish-meal. This number translates into roughly 2.44 pounds of fishmeal to produce 1 pound of salmon and roughly the same number to produce a pound of shrimp. Both of these industries have surpassed natural fisheries and since the price of wild stocks has fallen dramatically, many fishermen who were working in wild salmon fishing sectors have been driven out of business and being displaced to aquaculture operations.\[5\]. The salmon aquaculture industry in British Columbia of Western Canada has been studied extensively as an example of how aquaculture negatively affects the natural stocks at the same time. Since Canada is a developed country and has environmental regulations that are more rigid than those adopted in the Southeast Asian countries that culture shrimp, there are far less environmental catastrophes taking place, but the operation is dramatically affecting the ocean ecosystems of the region.

Salmon farming in British Columbia was introduced to the area in the 1970s as an alternative to natural stocks of salmon which fluctuated on an annual basis.\[8\]. However, the scale of operations increased dramatically when Norwegian capital flowed into the region starting in the late 1970s. Since then, most of the natural stocks have been replaced by cultured Atlantic farms (an exotic species introduced to the region due to their better growth rate). However, introducing a new exotic species into the region and having it compete alongside the native species of Pacific Salmon are thought to be the reason leading to the dramatic decline of the native species. Salmon farming is a closed aquaculture system, meaning that the eggs were hatched in artificial hatcheries made at various parts of the river in incubation boxes so that they would never mingle with the wild stocks. These salmon would later be kept in closed pens that were usually located near the river delta. Although the operation has always remained as a closed system, there have been large number of juveniles and mature salmon that have escaped into the river.\[12\]. Since the introduction of the
aquaculture system until 2001, it is estimated that a total of 255,000 farmed salmon have escaped into the wild and colonized the river systems throughout the province. Furthermore, there are reports that native populations have been wiped out in at least three rivers and the colonizers have settled in [8]. Even after knowing the detrimental effects that salmon farming causes, the industry continues to thrive, accounting for a total of Canadian $150 million per year in revenue in 1990; accounting for half of the aquaculture sales in Canada (Marine Fisheries Review, 2000). This example shows that aquaculture and its unfavorable effects are not specific to developing countries, but the developed world as well. Salmon farming is currently practiced on a large scale in: Canada, United Kingdom, Norway, Chile, and Japan on a smaller scale. Four of the five countries listed above are developed countries [3].

Aquaculture in relation to land based farming/wildlife systems

The source of feed that is currently used in the aquaculture system around the world and the feed that is being fed to land based organisms show an overlap. This has been discussed briefly in the section of how aquaculture products affect natural stocks, but in this section, some of the effects on the other food producing sectors will be examined in detail.

However before going into the details of feed used for aquaculture and the poultry industry, it is important to take note of water resource interaction amongst these two sectors. As stated before, aquaculture facilities in coastal areas cause serious environmental effects to the surrounding terrestrial ecosystem. However before this happens, keep in mind that most of the aquaculture facilities are located in river deltas/coastal areas. This means that many farms that produce livestock/agriculture are located in areas that are located upstream. In addition in some instances, factories and urban sewage contain excess nitrogen which is the source of the water supplies used in some aquaculture farms. When this excess nitrogen water is used in fish farms, it can make the species in the farm contaminated and susceptible to disease. In addition to this, many shrimp farms in coastal areas were planned in an inappropriate manner and clustered too close to each other [11]. This puts extreme stress on the shrimp in one farm. Even when a single shrimp is affected with the White Spot Virus [a shrimp disease that creates white spots on the shrimp and eventually kills off the shrimp in a matter of a few days], it will rapidly spread through the farm.

In many instances, these sick shrimp were then consumed by ducks that were released into the particular farm in order to act as pest management agents and they would later travel to wetlands [4,11]. These ducks would travel long distances in some instances and contaminate wild bird species with the virus (HPA1 & H5N1 viruses) which led some people to suspect that wild water birds were responsible for the spread of the these viruses. Just in 2005-2006 alone, the H5N1 virus alone has moved spread from south-east Asia to Northern China, Mongolia, Kazakhstan, southern Russia, eastern Europe, central parts of Europe, Middle East, Africa, and India. Furthermore, there is strong evidence that these viruses have been spread by wild water from the spread of the virus in 2005. In October of that year, outbreaks of HPA1 and H5N1 in Romania, Turkey, and Croatia have all been associated with wetlands. Located in other parts of the lake where the wetland was located were carp aquaculture sites. In this manner, the spread of the HPA1 and H5N1 virus currently is thought to be caused by water birds. These birds act as the agents who carry the virus to a particular wetland area which infect migratory birds which nest in the region.
However, this is not the only area that we can witness a strong relation between fish farming and poultry. These programs are usually called ‘Integrated Fish Farming’ or ‘Integrated Agriculture Aquaculture’ techniques. These programs make use of products of animal farming as food and fertilizers for fish farms. In some instances, pig pens are located directly above fish ponds, so that excreta and spilled food drop directly into the ponds and consumed by the terrestrial organism in the pond. In some of the other systems, fish pond usage is rotated between fish and crop production, and rice fields can also be flooded for fish rearing between rice crops [4]

What is then interesting is to note how fish aquaculture can affect water resources. In many fish farming operations, the water supply is fed by surface water (running in from the adjacent river system) or from ground-water supplies (located in the aquifers underground. The pH in natural waters that are unaffected by pollution is in the 6.5-8.5 range. However because fish require oxygen supplies in the water system in order to grow in addition to the fish pellets, the water supply in these ponds is affected by the clustering of terrestrial organisms and excess bacteria. During night, these factors can lead to the production of carbonic acid, bicarbonate HC03- and H+ ions to be produced. The H+ ions eventually become abundant and can cause the pH levels to rise. In productive ponds (intense operations) the daytime pH can go as high as 10 which can be lethal to young fish (Summerfelt). If this water is later used in the rice ponds, etc. they can affect the growth of the crops in that pond as well.

A New Farming attempt (Blue fin tuna)

It is a fact that the existence of blue fin tuna is known to be a special fish to the people of Japan. Throughout much of the 20th century, blue fin tuna around the world were caught, frozen, and sent to Japan and sold the following morning in the Tsukiji market. Ever since Japan started gaining economic strength in the 1970s, the demand for toro (fat taken from blue fin tuna) has continued to rise. In addition, as refrigeration techniques improved, blue fin tuna from countries further away were also imported and sold on the market [1].

However with the rise of the sushi boom, the demand for blue fin tuna has also increased. Japanese consumers themselves were already were stressing the supply of blue fin tuna around the world. Throughout the 1970s-1980s, Europe was a large supplier of blue fin tuna to Japan. However, there was a so called Gold Rush mentality amongst European fishermen and they have seriously depleted the natural stocks. In addition, during the last decade of the 20th century, demand for blue fin tuna rose world-wide. Many companies knowing that many of the natural fisheries in the Atlantic and Pacific Ocean started blue fin tuna farming. However, farming these highly migratory species is not easy since they favor different water temperatures. When the operation was in its initial stages, large numbers of blue fin tuna did not survive and died before they were consumed by human beings. The Japanese getting worried with depleting natural stocks invested heavily in the fisheries around the Strait of Gibraltar. These farms are owned by the Spanish, but in reality are comprised by technologies and funding from many developed countries. For instance, one farm relies on French purse seiners to retain tuna in their pens. The farms are joint ventures between Spanish/Japanese trading companies, using Spanish workers to carry out the operation using cultural techniques developed in Australia, fishmeal sent from various European countries,
and computer technologies invented by the Japanese in order to monitor the tuna \[1\]. This might seem like a nice way of sustaining the fishery but the first section; the fact that captured tuna are carried to their pen shows the largest mistake of this operation. Since blue fin tuna, along with other types of tuna are highly migratory species, it is not known where they spawn. Thus juvenile tuna from around the world that have not spawned when they are captured are brought into these pens. This would mean that the farming operation will decrease the stock in the long run because there are no juvenile tuna being born. Furthermore, as pointed out in the beginning of the tuna farming operations, many blue fin tuna do not survive until they are sent to seafood markets around the world \[7\].

**Alternative to the current Aquaculture System**

Much of the discussion so far has been on the negative aspects of the aquaculture industry and how unsustainable it is. Therefore we turn our attention and think for a moment about how we can build an aquaculture system that is more sustainable for the fish stocks and for the people associated with it. According to the environmentalists who study the effect of aquaculture on the natural/social environment, there are several fisheries that improve the well being of the local people and do not largely impact the ecosystem of the surrounding areas. According to some environmentalists, pearl oysters are filter feeders and feed low on the food chain and produce a luxury product, pearls, at the same time as producing food \[11\]. These products cost little to the environment and bring positive effect to the local and national economies.

As another example, we can highlight the traditional aquaculture system practiced in China as being another sustainable aquaculture system. As discussed before, carp feed low on the food chain and it has been cultured for 3000 years. During that time, local knowledge has found it sustainable to culture several types of carp together and maintain a poly-culture system. By doing this, the farmer can avoid using any type of feed and the fish would provide the necessary nutrients for each other. In addition, the various species of carp would cooperate with each other and maintain the water quality of the pond that they are kept in. We need to diversify the types of operations of the aquaculture farms in order to take the pressure off of the natural feeds. Currently the developed world is focusing only on producing high-value species (salmon, shrimp, and tuna) which are carnivorous species which are placed highly on the food chain. As natural stocks of fish keep in decreasing in volume, we have to think of a viable way in order to make the aquaculture industry thriving.

**Conclusion**

Aquaculture if practiced correctly can lead to food security, while putting minimal pressure on terrestrial ecosystems. This is clearly illustrated in the example of the carp industry in China which has been practiced for over 3000 years. In this system, several types coexist in a single pond, cleaning waste and maintaining water quality amongst each other. As another example, pearly oysters are another good alternative for the people in the South Pacific countries. Culturing pearl oysters produce two goods at the same time; food and a luxury item, while providing minimal impact on the local terrestrial environment. This also protects the security of the people who are associated with its production. The local villages prosper economically and that gradually work itself up to the national level.
Yet, the reality is that we are making efforts to culture high-value products such as salmon, shrimp, and blue fin tuna. As illustrated in the paper, farming of shrimp and salmon is extremely inefficient. We currently use an average of 2.44 pounds of fishmeal to produce 1 pound of salmon/shrimp. This is currently made possible to the low prices of fishmeal which are extracted from natural stocks, but this is because natural fisheries supply more than 75% of our seafood supplies. In the future if aquaculture were to supply more than 75% of our seafood as we continue to deplete natural stocks, fishmeal could face severe inflation. In addition, currently there is a large surplus of the fishmeal which allows us to use it as feed for the poultry industry or the chicken industry, but these sectors could face severe shortages in the future. We need to rethink the methods of how energy flows in this sector. In its current state, we can say that it is extremely inefficient.

The high-value seafood sector is also leading to many environmental/ethical problems for both the people associated in its operations; and for the local terrestrial ecosystems. The salmon that escape from the salmon farms are escaping into the wild, endangering the local populations that have existed there for centuries. Shrimp farming leads to intensification and loss of mangrove forests that leads to increased vulnerability to wave erosion or storm surge. Also, the blue fin tuna industry is also vulnerable despite its advanced operations involving many developed countries. Due to the nature of blue fin tuna, it is extremely hard to control water quality and many of the fish die before they are ready for consumption. In addition, aquaculture is rapidly getting integrated with agriculture, poultry, and even is affecting wildlife. In the section above, it was noted that the feed used for aquaculture is now being used to feed the poultry industry. However the opposite is currently taking place as aquaculture operations become increasingly correlated with the agriculture and poultry sectors. Waste that is generated from the livestock in some instances is fed to the terrestrial organisms and pond operations between aquaculture and agriculture become more common. This especially applies to the Asia Pacific region where more than 90% of the cultured products in the world are produced. In addition, wild birds that are released into aquaculture ponds are thought to be responsible for spreading viruses such as the HPA1 and H5N1 viruses. Furthermore, intense aquaculture production is putting immense stress on groundwater supplies and changing its pH levels, making it impossible to use in livestock and aquaculture operations as well.

Indeed aquaculture is a viable alternative to the depletion of natural fisheries; but only if it were used correctly. We (consumers of the developed world) have to rethink our diets and understand that aquaculture would not be able to continue if it keeps on being practiced in its current way (producing high-value products). Yet as the ancient Chinese have proven, there are ways to make the aquaculture sustainable and we must do something to reverse the trend before it is too late.

References
Case Study 2 - A brief introduction to the trans-jurisdictional water quality issues in China
(by Yi Zheng, Center for Water Research, Peking University)

Introduction

Trans-jurisdictional water pollution has become a very serious issue in China. In some cases, it even caused disputes that have to go to the highest levels of the central government for resolution. Typical examples of trans-jurisdictional water pollution in China include: pollution from upstream administrative regions (e.g. provinces, municipalities and counties) deteriorates the water quality of the water bodies in the downstream ones; and several administrative regions discharge pollutants into one large lake.

The increasing trans-jurisdictional water quality issues in China are rooted in its legal and institutional framework for water governance. In addition, the lack of a good water ethics framework aggravates the problem. Thus, to tackle trans-jurisdictional water quality issues in China, an improved legal and institutional framework and new water ethic are necessary.

An extreme case: Blocking-dam dispute

In mid 1990’s, the printing and dyeing industries in Shengze (a town in Wujiang City, Jiangsu Province) began to boom. These industries generated a great amount of high-pollution wastewater. Due to the local protectionism, the effluents were not rigorously regulated, and severely contaminated rivers which drain into Jiaxing City (in Zhejiang Province). The pollution dramatically deteriorated the water quality in Jiaxing, which posed great health risk to its residents (more cancer cases had been reported among the population that accessed the contaminated water), and caused significant damage to its agriculture and fishery. Due to the lack of economic incentive, effective regulation enforcement and dispute resolution, the pollution as well as the dispute it caused continued.

Eventually, the residents decided to protect themselves in their own way. On November 22, 2001, the furious residents in Jiaxing built a dam with sunken ships and blocked the water course of the MaXiGang River. This action was in serious violation of multiple laws and regulations, and got immediate response from the State Council and the Ministry of Water Resources (MWR) and State Environmental Protection Administration (SEPA). With the coordination of the central government, an agreement was finally reached among the two municipalities, as well as the two ministries (MWR and SEPA). Significant efforts were made to persuade the residents, since they were not willing to remove the dam until they saw the water quality improvement. Measures of pollution control were started immediately after the coordination meeting, and water quality compliance first achieved on January 11, 2002.

This story has been reported in Chinese mass media. After the event, the effluent control was improved, but the water pollution remains a problem since illicit discharges occur from time to time, and no effective measures were available to fully address the trans-jurisdictional water quality issue.

Water governance system of China

As said before, trans-jurisdictional water quality issues in China are rooted in its legal and institutional system for water governance. Figure 1 depicts the system. On the legislation side,
China’s National People’s Congress (NPC) established two major laws for water governance: Water Law (2002) and Water Pollution Prevention & Control (WPPC) Law (1984, amended twice in 1996 and 2008). Unfortunately, there are overlaps between these two laws, especially regarding water quality management, which causes many problems in regulatory practices.

On the administration side, China has a hierarchy system of territorial government. State Council is the central administration unit which directs MWR and SEPA. MWR and SPEA work under the Water Law and WPPC Law, respectively. The overlaps of the two laws resulted in the conflicts of the two ministries in water governance, especially when water quality is concerned. At the province, municipality and county levels, water resources bureaus (WRBs) and environmental protection bureaus (EPBs) are counterparts of MWR and SEPA, respectively. However, as an institutional setting, a local bureau only reports its corresponding local government, not the bureaus or ministry above it. A higher bureau has no mandatory power over a lower one. Furthermore, a bureau is financially supported by the local government whose budget mostly depends on its local GDP. All these tend to promote local protectionism. In addition, WRBs and EPBs have the similar conflicts as those at the central level.

Figure 1: Water governance system in China

**River Basin Organizations (RBOs) in China**

According to international experience, River Basin Organizations (RBOs) are a general solution to addressing trans-jurisdictional water quality problems. In fact, China already has seven major RBOs in China, supervised by MWR, including: Yangtze River Conservancy Commission, Yellow River Conservancy Commission, Huaihe River Conservancy Commission, Haihe River Conservancy Commission, Pearl River Conservancy Commission, Songliao River Conservancy Commission and Taihu Lake Basin Authority. These organizations have been more or less effective in trans-jurisdiction water governance with
regards to quantity, but not quality. We use Yellow River Conservancy Commission (YRCC) as an example, as briefly introduced below.

From early 1970s to 1999, zero-flow events occurred almost every year in the downstream of the Yellow River. A centralized water allocation system was then started from 1999 for the Basin, administrated by YRCC. Some important measures include: integrated basin level water resources assessment and planning; water right allocation to provinces in the basin and downwards to municipality and county levels; and a strict monitoring system (e.g. monitors at water intakes, meters in the pipe system, etc.). These measures have been effectively enforced, and no zero-flow events occurred since 2000.

YRCC has a subdivision called Yellow River Basin Water Resources Protection Bureau (YRBWRPB) which connects YRCC with local WRBs and EPBs. YRCC’s water quality management function is mainly in this subdivision. Nevertheless, in this basin, many trans-jurisdictional water quality problems remain unsolved. YRCC and its YRBWRPB are directly led by MWR. Although YRBWRPB also takes advice from SEPA, it has little jurisdiction for pollution control or trans-jurisdictional pollution management. In addition, in YRCC and its YRBWRPB, there is no representation by basin stakeholders.

Discussion

The main causes of significant trans-jurisdictional water quality issues in China can be summarized as below:

- The overlap of the WPPC Law and the Water Law leading to the overlap of institutional responsibilities of MWR and SEPA and their local counterparts;
- The failure to capture in the laws the necessity for integrated water quantity and quality management and control;
- The failure of local authorities to enforce the existing laws and to implement administrative decisions. Local protectionism is one of the major causes for trans-jurisdictional water quality problems;
- The lack of transparency in the decision-making process for water quality management, insufficient public participation and information disclosure, poor communication, and lack of involvement of stakeholders in river basin organizations;
- Improper basin-wide planning and management;
- Ad hoc measures for trans-jurisdictional water quality governance and dispute resolution.

To better address the trans-jurisdictional problems, the key is to create a mechanism, not to solve the problems case by case. General suggestions may include:

- Enforcing compliance;
- Improving monitoring system;
- Conducting legal and institutional reforms (legislation, administration system, judicial procedure, etc);
- Promoting data and information sharing;
- Performing integrated basin level management and planning;
- Utilizing market force;
- Establishing emergency response and reporting system.

In addition, original scientific studies are highly needed to provide adequate methodology and tools for trans-jurisdictional water quality management. Last but not least, a good water
Ethic should be established in China as one important supplement to regulations and economic incentives. Nevertheless, water ethics is a very new topic in China, further studies and discussions are in urgent need in this field.
Case Study 3 - Computer-Aided, Community-Based Water Planning: Gila-San Francisco Decision Support Tool
(by Amy Sun, Sandia National Laboratories)

Introduction
There is a long history of struggle over access to water in the arid southwest, and water allocation conflicts in the southwestern region of New Mexico are no exception. The legislation surrounding water management of the Gila River (pronounced “hee-la”) lasted almost fifty years. Figure 1 shows the map of the southwestern region of New Mexico surrounding the Gila River.

Figure 1 – Upper Gila region spanning New Mexico and Arizona states. The three outlined basins are study regions of the GSF Decision Support Tool. Red circles indicate USGS gauges.

The Gila river and its tributary San Francisco river begin in New Mexico, pass through the State of Arizona before merging into the Colorado River. The Gila-San Francisco Basin covers around 9,000 square mile region of Southwestern New Mexico. The Gila Wilderness Area, the first designated Wilderness area in the United States, resides in the basin and houses several federally listed endangered species: Southwestern willow flycatcher; Loach minnow, and Spidedace \[1\]. The agricultural communities that utilize the surface water for irrigation along Gila riparian region also date back to 1800s before New Mexico Statehood \[2\].

Section 212 (d) of the Arizona Water Settlements Act of 2004 (henceforth 2004 AWSA) modified Section 304(f) to allow the Secretary of Interior to contract with water users in the State of New Mexico, with the approval of its Interstate Stream Commission (NMISC), or with the State, for water from the Gila River, its tributaries, and underground water sources in amounts that will permit consumptive use of water in New Mexico not to exceed an annual average in any period of 10 consecutive years of 14,000 acre-feet, over and above the current legal maximal consumptive uses granted by article IV of the decree of the Supreme Court of the United States in Arizona v. California \[3\]. Such increased consumptive use can occur only as long as delivery of water does not diminish water supply for users in downstream Arizona.
The stipulations within the 2004 AWSA for which additional consumptive use can occur for New Mexico are known as the Consumptive Use Forbearance Agreement (CUFA) [4].

CUFA places several constraints under which the water can be diverted from the Gila river, none of which can be violated before water can be diverted. Table 1 summarizes the CUFA constraints. A cumulative constraint is defined as a constraint that does not limit a daily diversion quantity until it accumulates to its maximum legal limit. A daily constraint is a legal requirement that must be met on a daily basis. Understanding the current water supply scenario with added CUFA potential diversion is a major concern for the region.

More importantly, the 2004 AWSA provides between $66 and $128 million in non-reimbursable funds for New Mexico to develop water supply alternatives, including a New Mexico Unit of the Central Arizona Project [2]. The NMISC has committed to a continuing process of public information and comment to help arrive at such determinations.

In considering any proposal for water utilization, NMISC will consider “the best available science to assess and mitigate the ecological impacts on Southwest New Mexico, the Gila River, its tributaries and associated riparian corridors, while also considering the historic uses of and future demands for water in the basin and the traditions, cultures and customs affecting those uses.” [5]

Table 1 - Summary of CUFA conditions required for additional diversion of Gila-San Francisco rivers.

<table>
<thead>
<tr>
<th>Test</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Total &lt; 64,000 AF</td>
<td>Cumulative</td>
<td>Sum of Gila and San Francisco total consumptive use cannot exceed 64,000 AF per year.</td>
</tr>
<tr>
<td>Annual San Francisco Total &lt; 4,000 AF</td>
<td>Cumulative</td>
<td>San Francisco annual consumptive use cannot exceed 4,000 AF annually.</td>
</tr>
<tr>
<td>10-yr running total &lt; 140,000 AF</td>
<td>Cumulative</td>
<td>Running 10-yr total of Gila and San Francisco consumptive use cannot exceed 140,000 AF.</td>
</tr>
<tr>
<td>New Mexico CAP Water Bank &lt; 70,000 AF</td>
<td>Cumulative</td>
<td>The CAP Water Bank, as maintained by the federal agency, must never exceed 70,000 AF.</td>
</tr>
<tr>
<td>Gauged flow &gt; Daily Diversion Basis (DDB)</td>
<td>Daily</td>
<td>DDB is the amount of water that the downstream users in Arizona are entitled to and must be satisfied before withdrawal is allowed.</td>
</tr>
<tr>
<td>Daily San Carlos Reservoir &gt; 30,000 AF</td>
<td>Daily</td>
<td>San Carlos Reservoir provides water use to its downstream users. Minimum storage amount in the San Carlos reservoir is required before any consideration for withdrawal.</td>
</tr>
<tr>
<td>Sum of withdrawal &lt; 350 cfs</td>
<td>Daily</td>
<td>Combined withdrawal of rivers cannot exceed 350 cfs.</td>
</tr>
<tr>
<td>Gila Virden gauge &gt; 120% of Duncan-Virden Valley call</td>
<td>Daily</td>
<td>Duncan-Virden valley straddles both New Mexico and Arizona and its daily irrigation requirement must be met. The USGS flow gauge near the town of Virden best indicates Gila River flow near the valley.</td>
</tr>
<tr>
<td>San Francisco gauges &gt; Required flow for Phelps</td>
<td>Daily</td>
<td>This section of the CUFA focuses on the water available for the mining company Phelps.</td>
</tr>
</tbody>
</table>
Dodge throughout the year.

<table>
<thead>
<tr>
<th>Gauged flow &gt; Potential flow</th>
<th>Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is a New Mexico mandate which requires a specified minimum flow imposed on the Gila and San Francisco rivers.</td>
<td></td>
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</tbody>
</table>

**Community-Driven Modeling**

Prompted by the 2004 AWSA and awareness for collaborative solutions, local, state, federal governmental entities teamed with NGOs to form a collaborative modeling team that focuses on building decision support software for understanding water demand and supply in the Upper Gila region of New Mexico. The process of collaborative modeling has implications that extend beyond southwestern New Mexico, beyond the borders of the United States, and beyond North America.

The team was formed in 2005 and has continued despite various political and funding shortfalls. The Team met bi-weekly between September 2005 and July 2007 via Web conferencing and conducted face-to-face meetings/workshops every quarter-year during that period. Due to a funding shortfall, the team only met four times between the fall of 2007 and the spring of 2008. Since the summer of 2008, the team resumed its virtual WebEx teleconferences and face-to-face meetings without a facilitator. Because of the lapsed time, the team make-up has decreased from fifteen representations to nine, as shown in Table 2. While it is difficult to pinpoint the cause of loss of memberships, the purpose of the meetings also transitioned from “model-construction” to “model-sensitivities” during those two periods.

One of the advantages of using Web conferencing is its ability to engage geographically diverse Team members across this vast rural region. Participation in these meetings is central to understanding user needs, enhancing communication among users, and receiving feedback from team members.

In addition to modeling collaboratively, the team’s feedback on the process is captured in anonymous surveys. Three has been conducted, one in 2006, one in 2007, and one in 2008. The results from these surveys indicate consistent satisfaction with the collaborative process over these years; nevertheless, the impression on the tool varies widely, and there is a general consensus that new membership is required to fully represent the interests in the region.\(^6\)

**Gila-San Francisco Decision Support Tool**

The Gila-San Francisco Basin is comprised of complex, highly interactive physical and social processes. These systems are continually evolving in response to changing climatic, ecological, and human conditions that span across multiple spatial and temporal scales. A modeling approach based on the principles of system dynamics has been applied to produce the GSF Decision Support Tool. System dynamics provides a unique framework for integrating the disparate physical and social systems important to water resources management, while providing an interactive environment for engaging the public.\(^7\)

Building models using system dynamics is based on a collaboration of ideas and inputs, as well as the feedback loops within each element of the system. “Model building should be a circular process of creating a model structure, testing behavior of the model, comparing that behavior with knowledge about the real world being represented, and reconsidering structure”
The feedback loops for the GSF Decision Support Tool consider supply-side hydrologic units of surface water supply, and both shallow and deep aquifer supply. The demand side includes industry, agriculture (crop irrigation), cattle, population, and riparian growth.

The GSF Decision Support tool has been designed with the CUFA constraints, with the following goals in mind:

- Given various constraints, how much water is available from where, when, and to what purpose?
- Given various constraints, how much water is in demand from where, when, and to what purpose?
- What are the tradeoffs among various approaches to managing this water?

In May, 2006, at the face-to-face Team Meeting, the team then developed a list of variables that they felt would be most influenced by change, or that most reflected uncertainty:

- Demand by category (residential, agricultural, municipal, industrial)
- Instream flow targets
- Population change
- Weather/climate (temperature, precipitation, climate change)
- Vegetation composition (density, type land use change)

The team then selected five key metrics for output:

- River discharge by reach, as influenced by diversion and legal constraints
- Water appropriated versus actual use
- Water in storage
- Management effects on water supply/demand
- Effects on aquatic/riparian species and river ecology

The model requirements and historical use data are painstakingly captured using the PowerSim software. There are several hydrologic components: groundwater, surface water, agricultural and riparian consumptive use, industrial and population demands, and terms of diversion based on New Mexico CUFA terms. Along with the model, the team created a desired list of schema that the stakeholders can evaluate using a user-friendly interface overlaying the model itself. The model homepage is the starting point from which users can select scenarios for Climate, CUFA, Population, Agriculture, Minimum River Flows, and Mine Leased Water Rights. Figure 2 shows the homepage of GSF Decision Support Tool.
Illustrative Result: CUFA Diversion Sensitivity to Minimum Flow

Model calibration and quantification of water availability under the 2004 AWSA are currently being assessed by the team. As an illustration using historical hydrographs between 1979 and 2001, annual potential diversion from the Gila River is shown in Figure 3. The key insight from the dynamic simulation shows that large year-to-year fluctuations exist. More importantly, there are years where the potential water for diversion is larger even with larger minimum flow requirement. This is counterintuitive to what most stakeholders had envisioned. This is due to the constraints placed on the other CUFA constraints listed in Table 1. The interactions of all of the CUFA requirements restrained diversion potential beyond what the stakeholders had anticipated. Addressing the minimum flow requirement alone may not necessarily reduce the overall diversion potential for surface water diversion. This example demonstrates the often “unintended consequences” exhibited in water policy which only a combination of credible modeling and sound communication can lead to effective water management.
Figure 3 - Gila River water availability using 1979-2001 historical hydrograph of USGS Gila gauge. The RED indicates annual allowable CUFA diversion with 300 cfs minimum flow requirement, while the BLUE indicates annual allowable CUFA diversion with 150 cfs. (This figure is only illustrative and cannot be reproduced without the permission of GSF Modeling Team.)

Summary

Collaborative, consensus-driven community modeling process enhances the ethical quality while balancing human interests, ecological demand, and natural resources. Use of a computer-aided tool like the GSF Decision Support Tool provides a platform for productive and engaging dialogues. Sandia National Laboratories’ technical expertise in providing decision support tools is well suited for creating neutral, open, and inclusive environment.

The advantages of a collaborative modeling process tolerate the Gila-San Francisco Decision Support Tool indicates an overall sense of ownership, integrated planning and enhanced insight. Nevertheless, the modeling process requires longer, iterative cycles that may not coincide with long-term funding. More importantly, the values associated with community learning and decision making are difficult to quantify.

Note:* Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.

References

[1] Endangered Species List of New Mexico
District, Gila Valley Irrigation District, Phelps Dodge Corporation, The Secretary of the Interior, and Other Parties Located in the Upper Valley of the Gila River.


Case Study 4 – The Status of South-to-North Water Diversion Project in China
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1. Introduction

China is short in water resources in general, with average per capita occupancy of water resources accounting for merely one fourth of the world's average. Worse still, the distribution of water resources is uneven in the country, which is rich in the south but deficient in the north[1]. The North China (Huang-Huai-Hai) Plain area contains about one-third of China’s population producing one-third of its GDP and cultivating two-fifths of its farmland. This activity is supported only by less than 8% of the nation’s water[2].

So schemes for large-scale diversions from the water-abundant Yangtze River (Chang Jiang) have been under consideration for over half a century, but because of their cost, complexity, and concerns over their adverse environmental effects, and the higher priority given to addressing flooding concerns on the Yangtze and Yellow River through large dam building, a full commitment to their construction has only recently begun[2].

![Figure 1 General layout of south to north water diversion](image)

The South to North Water Diversion Plan is composed of the Western Route Project, the Middle Route Project and the Eastern Route Project, and was launched in 2002. The project will become the largest civil engineering initiative in Chinese history in both scale and overall investment. It will make a great impact on the whole nation while facing a lot of problems. By 2050, the three-route project will channel 44.8 billion m³ of water from the Yangtze to the drought stricken north. The routes link together four of China's major rivers, the Yangtze,
Yellow, Huai He, and Hai He. The four basins constitute one-third of China's landmass and are home to over 700 million people. The Eastern Route Project and Middle Route Project are under construction, and the Western Route Project is still under discussion because of many questions about water availability/deficiency and biological/environmental protection.

2. The History and Status of South to North Water Diversion Planning

2.1 History

The strategic concept of developing the gigantic water diversion project was first put forward by the late Chairman Mao Zedong in 1952, who said: "The south has a lot of water, the north little. If possible, it is ok to lend a little water." In 1958, in a Great Leap era Political Bureau directive, the terms (NanShuiBeiDiao) appeared. Then a project planning office was established in the Ministry of Water Resources in December 1979[3]. Feasibility and environmental impact studies were carried out in the early 1990s [4]. During the five decades, the Chinese government studied numerous potential locations and constructed a series of small diversions in six different provinces. Finally, on August 23, 2002 the Chinese State Council approved the three part South-to-North Water Diversion Project and created a limited-liability company, to oversee operations and management. The project’s design integrates the efforts of numerous agencies, including the Haihe Water Resources Commission, Tianjin Hydroelectric Investigation, and the Design Institute (Eastern Route); Changjiang Water Resources Commission (Central Route); and the Yellow River Conservancy Commission (Western Route) (SNWDPT).

2.2 Status of South to North Water Diversion Planning

2.2.1 General Layout of South to North Water Diversion Planning

Since the earlier study on South-to-North Water Diversion started in 1950s, the following general layout of South-to-North Water Diversion has been worked out: three water transfer projects, i.e. Western Route Project (WRP) and Middle Route Project (MRP) and Eastern Route Project (ERP) will divert water from upper, middle, and lower reaches of Changjiang River respectively, to meet the developing requirements of Northwest and North China [5].

The layout is suited to three topographic terraces of the continent of China. The South-North Water Transfer refers to three sets of diversions, the Eastern, Middle and Western routes, each serving separate areas, with the exception of the coastal city of Tianjin, which will receive water from both the Eastern and Middle routes [5]. Situated in highest Qinghai-Tibet Plateau, WRP can control whole Northwest and North China, but only divert water for Northwest in upper and middle reaches of Huanghe River due to the limited water quantity in the upper reach of Changjiang River. Passing the west of the third terrace, MRP will divert water from middle reach of Changjiang River and its tributary, Hanjiang River, and the water can now travel by gravity to most parts of Huang-Huai-Hai plain. Passing the east of the third terrace, ERP will pump water north due to its lower diversion location [6]. The Service Areas of the all three routes include Jiangsu, Anhui, Shandong, Hebei, Tianjin, Henan, Beijing, QingHai, Gansu, NingXia, Shanxi, Shaanxi, Inner Mogolia. The total diversion water will reach 44.8 bcm or more. The beneficial population will be over 400 million.

The South-to-North Water Diversion is an important strategic measure in the optimization of water resources distribution of China. As the specific geographic location and the limited
water quantity of the water providing area, each of the West Route, the Middle Route and East Route has its own rational scope of irreplaceable water supply area, according to the requirement of relative regional economic development, the preparation of pre-construction and the ability of the state finance and other conditions. Portions of the eastern and central system are already under construction, while the western system remains in the early planning stages. The whole project has been carried out in Dec 27, 2002.

2.2.2 Eastern Route Project

This project will divert water from the lower reach of Changjiang north to supply water for the eastern Huang-Huai-Hai Plain with the termination in Tianjin City by raising water in stages through Beijing-Hangzhou Grand Canal.

There is plenty of water in the lower reach of Changjiang River, with mean annual water of 956 million m$^3$ entering sea, and more than 600 billion m$^3$ even in an extremely dry year. Therefore, ERP will have enough water to be pumped north, and the water quantity to be diverted is based on the scale of ERP. The rational final engineering scale of ERP was considered in planning. The development level in 2020 was taken as the objective planning scale and the successful diversion of water into North China as the first-stage objective. The water quantities to be diverted in various stages are respectively 8.9 billion m$^3$, 10.6 billion m$^3$ and 14.8 billion m$^3$.[7]

ERP will supply water for Jiangsu, Anhui, shandong, Hebei Provinces and Tianjin Municipality. In detail, the receiving areas will include the plain on the lower Huaihe except the hinterland and its east of Lixiahe Region and the northern plateaus in Northern Jiangsu, the areas on both banks of lower Huaihe River from Bengbu City and on both banks of Xinbian River in the east of Huaibei City and parts of Tianchang County in Anhui Province; the areas along Nansi Lakes and Hanzhuang Canal and Liangji Canal, parts of eastern Jiaodong Peninsula, and northern area which can not be irrigated by the water of Huanghe in Shandong Province Hebei Province and Tianjin City and its suburbs.

- Layout of ERP

ERP will be built on the basis of the existing water diversion project from Changjiang in Jiangsu Province, Beijing-Hangzhou Grand Canal, Huaihe harnessing projects and the other relative projects. ERP will consist of water conveyance system, impounding project, power supply system. Figure 2 shows the layout of this route.
The main projects contain the water conveyance and impounding project.

1) Water conveyance system

The water conveyance system will include the main diversion channel, pumping station, Huanghe-crossing project and the relative treatment projects.

a) Diversion channel

There will be two diversion locations, Sanjiangying where Huaihe River enters Changjiing and Gaogang where Beijing-Hangzhou Grand Canal crosses Changjiang. The diversion channel will be 1156 km in total length from Changjiang to Tianjin trunk route, including a 646 km section in the south of Huanghe, a 17 km Huanghe-crossing section, and a 493 km section in the north of Huanghe. There will be 740 km in a total length of subsidiary routes including 665 km in the south of Huanghe. Ninety percent of the diversion channel will be made for use of the existing river channels. Beijing-Hangzhou Grand Canal will be the trunk diversion channel. Some subsidiary diversion routes will be added to partial diversion channel sections [7].

b) Pumping station

The topography along Huanghe River means that the diversion spot will be lower than the surface near Huanghe by 36 ~37 m. It is needed to construct 13 pumping stations to pump water from Changjiang to southern bank of Huanghe with the total lifting height of 65 m. The water crossing Huanghe can now by gravity to Tianjin. In the south of Huanghe, there will be a stage for Nansi Lakes section, and three stages for each of other sections. There will be 67 pumping stations with the total installed capacity of 678 MW. 16 existing pumping stations with the installed capacity of 149 MW will be used [7].

In the first-stage engineering of 13 stages, 51 pumping stations with the installed capacity of 529 MW will be built. The characteristics of the pumping station of ERP will include low lifting height (2-6m), large flow (15-40m$^3$/s for each unit), long operating time (5000 hours/year for the stations in the south of Huanghe). Some pumping stations responsible for water logging drainage will have to be of operating mobility and high efficiency [7].

c) Huanghe-crossing project
The alternative of tunneling under Huanghe between Dongping County and Dong’e County of Shandong Province was selected. On the basis of long-term geological investigation and the Huanghe-crossing exploratory tunnel excavation, the relative units have found out the foundation structure and the karst development in the river bed under Huanghe, and solved successfully the problem of leakage control for excavation under the riverbed. Huanghe-crossing section is 7.87 km in total length from the outlet of Dongping Lake to the outlet gate of the north bank of the Yellow River, including a siphon section of 585.38 m. The two horizontal tunnels with the diameter of 9.3 m will be located 70 m under the riverbed of Huanghe. For the first stage of engineering, one of the two tunnels will be driven.

(2) Impounding projects

The impounding projects are necessary measures for long-distance water transfer. Along ERP in the south of Huanghe, there are some lakes such as Hongze Lake, Luoma Lake, Nansi Lakes, Dongping Lake, that can be used as the impounding projects for ERP with the total regulating storage capacity of 4.89 billion m³ through minor reinforcements and alterations. No new impounding project will be needed. In the north of Huanghe, Beidagang Reservoir in Tianjin City can be continuously used, and Tuanbowa in Tianjin City and Qianqingwa in Hebei Province will be extended for use, and Dalangdian and Langwa in Hebei Province will be newly built. So there will be 5 impounding projects with the total storage capacity of 1.49 billion m³ in the north of Huanghe.

In accordance with the price level in 2000, the total investment for ERP equals about 65 billion yuan. For the first stage engineering, some 32 billion yuan will be required. ERP will increase supply Jiangsu, Anhui, Shandong, Hebei and Tianjin with 14.8 billion m³ of water. The ERP completed will basically solve the problems in shortage of water resources in Tianjin Municipality, Heilonggang and Yundong regions in Hebei Province, north and southwest and part of Jiaodong Peninsula of Shandong Province, and make the supplying water for Tianjin available, consequently prompting economic development of Bohai Sea area and eastern Hulang-Huai-Hai Plain, and improving the environment from deterioration from the shortage of water. ERP will ensure the annual navigation from Jining to xuzhou on Beijing-Hangzhou Grand Canal, and make two commodity grain bases in Western Shandong and Northern Jiangsu strong and developed.

Present status

The first stage of the Yellow River Crossing engineering began on Dec 28th, 2007. Figure 3 shows the passionate construct scene.
2.2.3 Middle Route Project

The middle Route Project (MRP) for the South-to-North Water Diversion Project will divert water, in the near future, from Danjiangkou Reservoir on the Haijiang, a tributary of Changjiang River, to Beijing City through canals to be built along Funiu and Taihang Mountains. In the future, additional water is due to be obtained from the Three Gorges Reservoir or downstream from the dam on the main Changjiang. The advantages of this project lie mainly in the good quality of the water to be diverted, the greater water-supply coverage available, and that water can be conveyed by gravity. The project will be an important and basic facility for mitigating the existing crisis of water resources in North China.

It has been already 40 years since the earlier stage study on the MRP started in the early 1950s. In these years, Changjiang Water Resources Commission, and other relative provinces, cities, and departments have performed a lot of investigations, plans, designs and research works. In January 1994, the Ministry of Water Resources examined and adopted the "Feasibility Study Report on MRP for South-to-North Water Diversion" conducted by Changjiang Water Resources Commission, and proposed to build this project to the State Planning Commission.

- **Transferable water quantity and scope of water supply**

  Based on the completion of Danjiangkou Reservoir extension means that the annual water quantity to be diverted will be 12.0~14.0 billion m³, and 6.2 billion m³ for the dry year (95% guarantee rate). The normal water level of Danjiangkou Reservoir will be 170.0 m. In accordance with the development level in 2020, some compensative projects will be built on the middle and lower Hanjiang to ensure the development of industry and agriculture, and the navigation and the environment of the water exporting region.

  MRP will supply water for Tang Bai He Plain, middle and western parts of Huang-Huai-Hai Plain, with a total area of about 155,000 km². Due to the limitation of water quantity in Hanjiang River, MRP cannot meet all the requirements of planned water supply areas, only provide water for municipal and industrial use in Beijing, Tianjing Municipalities, and Hebei, Henan, Hubei Provinces, and give consideration to the agriculture and other use of water in some areas.

- **Benefits of project**

  MRP will mitigate the crisis of water resources in Beijing, Tianjin and North China, and increase the irrigated area by 0.6 million ha, 6.4 billion m³ for municipal and industrial water supply, 3.0 billion m³ for agriculture, for Beijing, Tianjin, Hebei and Henan, and significantly improve the biological environment and investment environment of receiving areas, and boost the economic development in Middle China. Heightening Danjiangkou Dam will increase the ability for flood control of middle and lower Hanjiang and assure the safety of Wuhan City and the plain in the north of Hanjiang.
Table 1 Annual mean of water diversion between service areas of MRP

<table>
<thead>
<tr>
<th></th>
<th>Water Supply ($10^9$ m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>1.02</td>
</tr>
<tr>
<td>Tianjin</td>
<td>1.24</td>
</tr>
<tr>
<td>Hebei</td>
<td>3.47</td>
</tr>
<tr>
<td>Henan</td>
<td>3.77</td>
</tr>
<tr>
<td>Sum</td>
<td>9.5</td>
</tr>
</tbody>
</table>

- **Layout of MRP**
  
The main works of MRP will be composed of two major parts: the engineering structures in the water source region and the water conveyance systems. The former includes Danjiangkou Dam Extension Project on the Hanjiang and compensative projects for its middle and lower reaches, and latter includes the main trunk canal for diverting Hanjiang and Tianjin main canal [8]. Figure 4 shows the layout of Middle Route Project.

![Figure 4 Layout of Middle Route Project](image)

- **Engineering structures in water source region**
  
  (1) Danjiangkou Dam Extension Project:
  
  Controlling 60% of the total drainage area of Hanjiang River basin, Danjiangkou Reservoir has a mean annual natural runoff of 40.85 billion m$^3$. Taking into account of the development of the upper reach, the reservoir was expected to receive a mean annual inflow of 38.54 billion m$^3$. Based on the engineering scale already in place, it is planned to continue to complete the Danjiangkou Project to its final scale, namely, to heighten the dam from its existing crest elevation of 162 m up to 176.6 m, with the design storage level raised from 157 m to 170 m and the total storage capacity consequently increased to 29.05 billion m$^3$ [8]. This means to gain, as against the initial figures, an additional reservoir storage capacity of 11.6
billion m$^3$, an increased available regulation storage capacity of 8.8 billion m$^3$ and an extra flood control storage capacity of 3.3 billion m$^3$\cite{8}.

The normal storage water level of Danjiangkou Reservoir will be at 170 m in its final configuration, with the additional inundated area of 370 km$^2$. In accordance with the investigation in 1992, the main inundation indices are as follows:

Earth excavation: 300 thousand people; Houses: 7.086 million m$^2$; Cultivated land: 0.01562 million ha.

(2) Compensative projects for middle and lower Hanjiang:

To transfer water of more than 14 billion m$^3$ in near future and avoid the available harmful effects on water use for industry, agriculture and navigation in the middle and lower Hanjiang Basin, it is required to construct Xinglong or NianpanShan Hydraulic Project on Hanjiang as part of the proposed main river canalization project and a water compensating project diverting water from Changjiang to Dongjianghe, and to modify or extend part of the existing sluices and pumping stations, and to build some additional navigation regulating works as well.

- **Water conveyance systems**

  (1) Main trunk canal

  Since the limitation of the location of the existing canal head, Fangcheng Saddle on the watershed between Changjiang and Huaihe Rivers, the range of passing Huanghe, the line of main trunk canal of MRP in the south of Hulanghe is clear. As to the main trunk canal in the north of Huanghe, two alternatives have been compared, utilizing the existing river channels or excavating new canals. In accordance with ensuring water quality and realizing of flowing by gravity in the whole route, the latter, excavating new canals, was selected.

  The main trunk canal starts at the Taocha canal head, passing the 8 km of the existing channel, northeast along the south side of Funiu Mountain, going through NanYang City and crossing Baitie River, will enter Huaihe Basin by passing FangCheng saddle on the watershed. Then, through Baofeng County, Yuzhou County, and the west of Xinzheng, the main trunk canal will cross Huanghe at Gubaizui in the northwest of Zhengzhou City, the capital of Henan Province, and extend on the North China Plain between the eastern Taihang Mountain and the western Beijing-Guangzhou Railway, and enter hilly area in Tangxian, and enter Beijing Metropolis by crossing the northern Juma River, and enter Beijing urban district by crossing Yongding River, and terminate at Yuyuan Pool. The total length of the trunk canal is 1273.72 km.

  Tianjin main canal is 140.82 km in total length, from the diversion spot on the main trunk canal in the north of Xiheishan in Xushui County, Hebei Province, to Xihe Sluice of Tianjin. The design water level at the head of main trunk canal is 147.38 m, and that at termination is 48.57 m. The water diverted can flow by gravity along the whole main trunk canal.

  The longitudinal gradient of the canal is 1/25000 for the sections in the south of Huanghe and 1/30000-1/15000 for those in the north of Huanghe. For the purpose of seepage control and roughness-reducing, the whole canal will be lined all along the route with concrete, cement-treated soil, shotcrete facing and the like in accordance with the foundation conditions. The design now for the canal is progressively reduced from the south to the north, with water depth decreased from 9.5 m to 3.5 m, and bottom width changed in the range of
The engineering geologic conditions and major geologic problems along the main trunk canal have been mainly made clear. As for some local engineering geologic troubles relative to bentonite and loess, such as canal slope stability, shock-induced liquefaction failure of sandy soils, earthquake resistance in high earthquake intensity region, subsiding of underlying coal and mined hollow zones, they all can be readily solved and treated by adopting corresponding measures. Linking up four major river valleys, Changjiang, Huaihe, Huanghe and Haihe, the main trunk canal (including the Tianjin main canal) will have to run across 205 rivers, medium or small, each covering a drainage area of over 20 km², inclusive of the main Huanghe, and 42 railways. It is thus required to build, on the main trunk canal, various structures, small-size, totally 1774, such as regulating, diversion and tailrace structures as well as tunnels and closed conduits, including 735 canal crossing highway bridges, the largest in scale of which is Huanghe-crossing Project.

(2) Huanghe-crossing Project

The main trunk canal will cross Huanghe in Gubaizui under the comprehensive planning of Huanghe Basin. Since its complex problems and large scale and investment, the Huanghe-crossing project will be the most critical structure on the trunk canal. Based on the comprehensive study and comparison among the many alternatives, the aqueduct and the tunnel siphon are technically feasible. Tunneling methods have proven successful domestically and overseas, so were recommended that the alternative of tunneling at Gubaizui would be adopted in accordance with the canals on both banks. The tunnels crossing Huanghe will be 7.2 km in total length. For it, the design water diversion now is 500 m³/s. The project includes two tunnels with the internal diameter of 8.5 m.

- **Investment**

There are two key factors controlling the construction schedule of MRP. They are Danjiangkou Reservoir resettlement and Huanghe-crossing Project on the main trunk canal. In accordance with the price level by the end of 2000, the total static investment for MRP equals to about 117 billion RMB.

- **Present status**

Work started in August 2005 on one of the key components of the middle route, excavating two 3.5-km long tunnels under the Yellow River and is expected to be finished in late 2009 [10]. The Shijiazhuang to Beijing section of MRP is finished. From the last golden week, 3 billion cubic meters water will be diverted from Hebei to Beijing by the canal in 2008.
2.2.4 Western Route Project

As the strategic project, WRP will divert water from the upper reach of Changjiang River into Huang River to solve the problem of poorer water in Northwest and North China. Since 1952 when an investigation team was organized by Yellow River Conservancy Commission (YRCC), the relative units have done a great number of investigation and plan and research works for more than 40 years. In 1987, State planning Commission classified WRP as a project of pre-earlier-stage study, and asked to make a 10-year study to assess the WRP. Since then, YRCC and other relative units have done a lot of basic work in nearby districts that are colder and more remote, with oxygen-lacking water, and submitted the “Preliminary Report on Western Route Project for South-to-North Water Diversion” and the “Findings Report on Yalongjiang Water Diversion Project” to the State Planning Commission and Ministry of Water Resources for examination. Up to now, the findings on Tongtianhe River and Daduhe River Water Diversion Projects have almost been completed [11].

- Transferable water quantity and scope of water supply

In 1950s and 1960s, it was considered to divert water from Tongtianhe, Yalongjiang, Daduhe, Lancangjiang, Nujiang Rivers. In the last decade, YRCC has focused on studying water transfer from Tongtianhe, Yalongjiang, Daduhe Rivers. In accordance with the initial study results, from those three rivers, the maximum transferable water quantity about 20 billion m$^3$, including 10 billion m$^3$ from Tongtianhe River, upper reach of Changjiang River, and about 5 billion m$^3$ from Yalongjiang, a tributary of Changjiang River, and 5 billion m$^3$ from Daduhe River. The water diverted will be supplied for Qinghai, Gansu, Shanxi, Shanxi Provinces, and the Ningxia Hui Autonomous Region and the Nei Mongol Autonomous Region [10].
Bayankala Mountain lies between Huanghe River and Changjiang River. The elevation of the bed of the Huanghe River is higher than that of the correspondent section of Changjiang by 80-450 m. It is necessary for the water transfer project that a high dam will be constructed for damming water or some pumping stations be set up for lifting water, and some long tunnels will be driven through Bayankala Mountain.

Two methods of water diversion, flowing by gravity and by pumping were considered. But for each of them, a high dam in height of 200 m or so will have to be constructed and some long tunnels over 100 km in length to be driven.

Preliminary study on water diversion route is as follows.

(1) Yalongjimg Diversion Route:
A diversion route by gravity was selected. The Hydraulic Project will be constructed on changxu Reach of Yalongjiang River, the water will be diverted from Changxu to Qiaqeinong Ditch, a tributary of Huanghe River. The height of the dam is 175 m, the diversion route is a tunnel, which is 131 km in total length.

(2) Tongtianhe Diversion Route:
This is a combining development scenario of the Yalongjiang and Tongtianhe diversion routes. The condition is that Yalongjiang diversion route must be the priority construction. The Hydraulic Project will be constructed on Tongjia Reach of Tongtianhe, the water by gravity will be diverted from Tongtianhe Project to Yalongjiang River, then, to Qiaqeinong Ditch. The Diversion Route is in fact a tunnel, 289 km in total length, including 158 km from Tongjia Dam to Yalongjimg River and 131 km from Yalongjiang River to Qiaqeinong Ditch, a tributary of Huanghe.

(3) Daduhe Diversion Route:
A diversion route by pumping was elected. The Hydraulic Project will be constructed on Xierga Reach of Zumuzu River, a tributary of the upper reach of Daduhe, the height of the dam is 296 m. The water by pumping will be diverted from Xierga Hydraulic Project to Jiaqu River, a tributary of Huanghe, total length of the diversion route is 30 km, including a 28.5 km tunnel. The lifting height of the pumping station is 458 m, the mean annual power
consumption is 7.1 billion kw*h. Figure 6 shows the general map of water diversion route of WRP.

- **Benefits of project**

  20 billion m$^3$ water from three rivers will be diverted by WRP to increase the irrigated area by 30 million mu and to supply living and industrial water by 9 billion m$^3$ for Qinghai and Gansu and Shanxi and Shanxi Provinces, and Ningxia Hui and Nei Mongol Autonomous Regions, consequently promoting the economic development of Northwest and inland areas, and improving the biological environment of Northwest Loess Plateau.

- **Technical feasibility**

  WRP will be located in Qinghai-Tibet Plateau, with an elevation of 3000-5000 m. For WRP, a high dam with the height of 200 m or so will be constructed, and some long tunnels over 100 km with the burden of hundreds meters will be driven in this very cold area which is also the one of areas with the most complex geological structure. The earthquake intensity of most parts of this area is over 6-7 degrees with the max intensity of 8-9 degrees on the modified-Mercalli scale. The construction of WRP with complex technology faces many difficulties of environment. Currently since the western route involves the greatest level of uncertainties and complexities, it is required to strengthen earlier-stage studies and scientific research to solve the above problems. The construction is not likely to begin anytime in the near future.

3. **Challenges of the project and related researches**

   The biggest challenges to the diversions are probably not ones of engineering or environment, but of institutions. These include the need to coordinate numerous provinces in an unprecedented way, the need to find an appropriate balance between public and private sectors while this is in flux nationwide, the politically charged nature of increases in water charges to cost recovery levels, ensuring adequate finance, and, more generally, the very real possibility of simultaneous market and government failures \[2\].

   With good reasons, much of the research of the three-route project are focused on water resources management, hydraulic control, and gate/channel control etc. The research contents of water resources management mainly includes:

   1) Water resources evaluation, with the methods of traditional water balance or new developed distributed hydrology model that combines the effect of human activity;

   2) Water resources operation, with the methods of mathematic programming, such as linear programming, nonlinear programming, dynamic programming etc., or other rule-based methods to allocate the water resources between different water users, now and future etc.

   3) Decision making support system, with the techniques of software engineering to utilize the models or experts knowledge to give a decision support for water resources operation.

**Reference:**


Case Study 5 - On Ethical Principles Concerning Water Diversion and Water Usage
(by Qingju Qiao, Department of Philosophy, Nankai University, Tianjin, China)

As residents of Beijing, the water we are drinking today is diverted and transferred from Danjiangkou Reservoir in Henan and Hubei provinces, about 1,300 kilometers south of Beijing. The two provinces are not the region governed by Beijing municipal government, neither are we the inhabitants close to the reservoir. Politically speaking, the local government of Beijing city does not have any legal power to divert and transfer water from a place other than its governing region, so the Water Diversion from South to North is a project at state level, planned by the Chinese central government and carried out by a special committee nominated by it. But ethically speaking, how can we do so? What ethical principles are involved in such kind of activity?

Human rights vs. Eco-rights: two starting points of ethical considerations

Human right for water is a fundamental human right

Water is one of the most essential resources for human being: everyone has a right to water for various kinds of usage for living. Thus the human right to water is one part of or one item of general human rights, accordingly, water right is a fundamental human right that cannot be deprived of by anyone or any kind of power. This principle is a postulation that evidently needs no argumentation here and from which we start our ethical consideration on water diversion and water usage.

Eco-system or Nature also has its own rights to water

The above conclusion is one that only comes out from considerations on the human side. However, as it has been already made clear that human beings are a part of, not isolated from or dichotomized from nature, and therefore we should also make considerations for the nature side. Firstly nature and the eco-systems have the right to exist, evolve and develop by its own course steadily and smoothly from the present level to a future level; it has a right or rights to water. This right, here called eco-right or nature-right, cannot be interrupted by human beings for any kind. Any action of such kinds would result in disasters to nature and eventually to human beings. Secondly, both humans’ and ecosystems’ rights to water are the two starting points for ethical considerations.

A prudential reader will surely detect immediately that there might be contradiction between the two points: how can we balance the water needs between human beings and nature? In the author’s opinion, human beings’ need is no more important than and takes no priority to the needs of other creatures’, and it subordinates to the whole eco-system or nature. Therefore, at least the quantity of our water usage should be scale-downed to one fourth of the usual amount. It is an eco-mistake for us, as the offspring of the evolution of nature, to stand on the opposite of nature and use it just for survival without any consideration of other creatures. In this case, admitting ecosystems’ right to water, leaving enough water for it, degrading our living level by reducing the amount of our usage is a more appropriate option. Thus the water mentioned thereinafter in this article is a remained amount after being taken away by the eco-system (the “water” in this paper is assumed to be clean water, only the quantity issue of water will be discussed).
New ownership of water: the precondition for ethical principles concerning water diversion and water usage

A country’s water is owned by all its citizens

By modern political theory, a country’s boundary is also the confine of its inhabitants’ right. For example, we can’t make a claim to any property existing in other country except we have paid properly. So a citizen of a country cannot use another country’s water except by paying money, by agreement or something like forceful occupation, just as what is happening now in the Middle East between Israel and Palestine, which is a much more complicated issue.

Just as any other kind of natural resources, water is not distributed geographically evenly within a country’s boundary. In some places, water, both surface water and groundwater, is in such an abundant state that their inhabitants are constantly being faced with the danger of flood; but on the contrary, there are also places that are in an urgent scarcity of water that people there cannot even maintain their daily life. Such is the real situation in contemporary China. Statistically, the average water possession per person in northern china is just one third as many as that in southern china, big northern cities such as Beijing, Tianjin etc. and a large number of northern rural areas are in serious shortage of water. Under the same sky and within the same boundary, such an uneven situation can’t be thought of normal for a country’s balancing development, especially, of just and equal for every citizen. To make water divertible from one place to another we must ethically presume that a country’s water is owned by all its citizens, every one of its citizens has an equal right to water in his country everywhere. Here lies the ethical validity of water diversion, consequently there emerges every kind of water adjust and diversion projects in china, of which, the project of diverting water from south to north is the most famous one.

A new kind of ownership: an overlap kind of ownership

When saying that something is owned by a group of people, we would think that it can be divided into equal or unequal parts as many as the numbers in the group. For example, a company belongs to all its shareholders; everyone knows how many his share is, and can sell or buy other’s shares. This kind of ownership can be called “shareholder’s type of ownership”. Contrarily, the type of water ownership is stemmed out from and a part of one’s fundamental human rights, it can’t be divided into parts and be given to any one of the group, otherwise it would result in the deprivation of human rights. Thus, for understanding the human rights to water, a new kind of ownership model is brought forward. As shown in Figure 1, supposing that A and B are two persons or two family or juridical persons, M and N are one road or one property that can be divided into parts.
Figure 1: Diagram of a new ownership model

Here assume A and B together own the road MN, which can be divided into part M and part N. By the shareholder’s kind of ownership, A owns M, B owns N, A can buy or by any other means get N from B and vice versa. This will result in a situation that there is no road for B or contrarily no road for A, neither of the case could be called just and equal. Thus, we would look forward to a new kind of ownership, which is an overlap type of ownership. By this type of ownership, A’s right is identified with M plus N (A=M+N) and so does B’s right, therefore every inch of M and N is simultaneously owned both by A and B. Cut any part of M or N off would surely be a damage of right not only to A but also to B. If A and B stand for all the citizens of a country, including its future generation, and M and N are all the water resource of the country, this would become the model of an overlap type of water ownership of water. That is to say, everyone has the same right to all the water within the country’s boundary. This model of right, basing on the equality and justice, is the profound principle that makes water diversion ethically acceptable. It might be pointed out that we should as well know that as the most fundamental principle concerning human right to water, it can, in contemporary China, only be guaranteed by the central government. Furthermore, because it is an abstract concept, if making this take actual effect in real life, we must go a step further to solidify it by principles concerning actual water usage.

Principles regarding practical water diversion and water usage

There are 6 principles that are important concerning practical water division and water usage. These principles do not exhaust all the principles that might be deemed important for this theme. The number of principles might be increased and their demonstration might be intensified or promoted as studies go on.

Principle of equality of water right

In actual life, this equality of water right can be concretized into the equal quantity of humans’ basic amount of water for living, which can be calculated into a concrete number. The equality of water right means that everyone has a right to possess the same basic amount, with (or without) an added amount for comfort. Extravagant consumption of water should not be included in the number.

Principle of vicinity

The principle of vicinity is quite evident: even though one has a right to the water in his/her country, it is still unimaginable that he/she, for example, being a resident of Beijing, drinks water every day from Changjiang River or Zhujiang river, which are 1200 miles and 2000 miles away respectively. It means that when people need to use water, for the convenience of locality, the first choice is to use water sources close to them. This principle gives people who live closer to water sources the precedence in using it than those who live farther than them. However, it should be point out that this precedence is not a privilege; instead, it is merely a kind of interest coming out from a favorable situation. It is a factual right, not a legal one. What is more, it is much more a responsibility than a right, that is to say, if one person lives closer to water and has more convenience using it than others who live
farther, he also has greater duty to prevent it from pollution and destruction. Like what Theodore De Bary said: “to think globally and to act locally”.

**Principle of frugality**

The third Principle is frugality, which means that people in the vicinity of water should not use water exceeding their necessary needs, i.e., the basic amount plus a small amount for comfort. Except leaving a certain quantity of water to the local ecosystem, they should also leave water for the people of other places where there is a lack of water and for future generations. To balance water usage, a government can, within the limitation of ecosystems, adjust water between places of surplus and those of deficiency, so as to respect equal access rights to water right. How to adjust water among places will be the content of the fourth principle.

**Principle of quantified allocation**

To make this principle practicable, there is a need to measure the amount of necessary need. To calculate the total amount of water needed in a region for domestic, agricultural, industrial, and commercial uses, is both an ethical issue and a scientific one. The Yellow River Committee is a typical Chinese governmental department that does this kind of tough job, namely, the allocation of yellow river’s water for the provinces along it every year.

When looking beyond the boundary of a country and view things globally, how to allocate water among countries with water shortages would be the burden of UN, and how to articulate principles regarding globally water allocation will surely be the academic burden of the Working Group 14.

**Principle of transaction**

The allocated water amount, if being saved, could be sold out as a kind of commodity in water market, this is the fifth principle - the principle of transaction. Special kind of water such as mineral water should be excluded out of basic amount for living; it could be sold out to a commercial entity for making water commodities, just as other mineral resources.

**Principle of compensation**

The last but not the least, is the principle of compensation. As users of nature, we must compensate nature; as users of other region’s resources, we must compensate those people there, who have degraded their living standards because of resources being transferred away from them. How to compensate nature and people will be studied by scientists and philosophers of ethics.

**A model of practical water usage**

At the end of this paper, a model of practical water usage is proposed. As shown in the Table 1: the first column illustrates the categories of water; the second column suggests the order of importance for various water uses; the third one denotes the water uses and the fourth one shows the concrete usage of water. The number in this column also indicates the order of importance.
Table 1 Categories of water and their different usage

<table>
<thead>
<tr>
<th>Categories of water</th>
<th>Order of importance</th>
<th>Usage of water</th>
<th>Concrete usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>general kind of Water</td>
<td>I</td>
<td>Eco-usage</td>
<td>Human usage</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Local usage</td>
<td>1.for living</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.for agriculture,</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Ecdemic usage, water diversion</td>
<td>3.for industry,</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>others</td>
<td>4.for commercial</td>
</tr>
<tr>
<td>Special kind of water</td>
<td>For commercial usage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Case Study 6 – Teaching Plan on Water Crisis in the High School
(by Jinhua Fu, the High School Affiliated to Beijing Normal University, China)

The High School Affiliated to Beijing Normal University, founded in 1901, is one of the well-known secondary schools in China. Bioethics has been chosen as an elective course for five years, which was introduced by Darryl Macer. The textbook used is *A Cross-Cultural Introduction to Bioethics* supplied by Eubios Ethics Institute, including sixteen chapters, such as genetic privacy and information, brain death, organ donation, HIV and ethics, genetically modified organisms, clone, animal right, assisted reproduction, hospice care, and sustainable development. Water crisis is also one of the contents in this course. Water crisis is a term that refers to the status of the world’s water resources relative to human demand. The major aspects of the water crisis are overall scarcity of usable water and water pollution.

1. **The purposes of offering course related to water crisis**
   Water wasting is very common phenomena among teenagers. If you criticize them, they will tell you: “I admit water is very important in our lives, but I always waste water, which hasn’t caused any troubles. Why should we save water? There is a lot of water in our country, and the water is continuously flowing in the water pipe. When I am thirsty, I could buy the mineral water or the orange juice. You know, that’s not very expensive. I could pay for my waste.” This is just one typical case in the high school. They even don’t know in the west part of China, lot of people cannot get enough and clean water for their daily lives. So it is an emergency to prepare a lecture on water crisis. The aim is to enhance the students’ consciousness to save water and concern about the water resources.

2. **Approaches**
   (1) Introduce some basic knowledge about water resource in China, such as the quantity and the quality of the water. According to the statistics, China's per capita volume of water resources is only 2300 cubic meters, which is only 1/4 of the world's average.

   (2) Describe some problems caused by water
   There are several principal manifestations of the water crisis, such as inadequate access to safe drinking water in the west part of China; groundwater overdraft leading to diminished agricultural yields; overuse and pollution of water resources harming biodiversity, and regional conflicts over scarce water resources sometimes resulting in warfare.

   Here we take Taihu Lake as an example of water bloom. Located in the southern part of the Yangtze River delta, Taihu Lake is the third largest freshwater lake in China, and it is a famous scenic spot in China and is famed for its lake, its hills and its man-made scenery. There is a very famous Chinese song, named the beauty of Taihu lake:

   The beauty of the Taihu Lake is for its water
   where white sails give free chase
   and red chestnuts grow underneath
   and greenish reeds gather by the lakeshore
   while plump fish and shrimps roam ashore
   the lake water maps a network of irrigation
   scented by ripe rice and fruits
Such beautiful pictures in our mind, but things are different in June, 2007. Taihu Lake suffered a serious pollution problem of blue algae. The waters give off bad smell which makes people uncomfortable. Then the same thing happened in Dianchi Lake in Kunming, Yunnan province. Meteorological departments forecast that these lakes are still having the possibility of water bloom in the following years.

In fact, the students had learned this in the biology class. Nitrogen and phosphates are the culprit. So, some questions were designed to the students: “What caused the water bloom? Who dumped these compounds into the water? Who should take the responsibility for this event? Should they get punishment? What kind of measures should the government take? If you are a manager of the fertilizer company, what will you do? Have you ever thought about the bad result for the waste? Would you like to install a "Cyclator" to treat the waste water? Would you like to spend some money on it?”

Bioethics class is different to the biology or geography class. We hope the students could analyze this case, use the principle of water ethics, discuss with their partners, and find the right way to solve these problems.

Another example is water pollution and the impact to health. Waterborne diseases and the absence of sanitary domestic water are one of the leading causes of death worldwide. For children under age five, waterborne diseases are the leading cause of death. At any given time, half of the world’s hospital beds are occupied by patients suffering from waterborne diseases. According to the World Bank, 88 percent of all diseases are caused by unsafe drinking water, inadequate sanitation and poor hygiene.

Biological concentration is also a serious problem, which means the process by which some contaminants, including heavy metals and herbicides or pesticides) in environment are taken into in the body through the food chain. Since these contaminants are generally chemically stable, biological concentration will increase along the food chain, like DDT which was narrated in Rachel Carson’s book, Silent Spring. As we know, the heavy metals in the water also caused itai-itai disease and Minamata disease in Japan. Even in China, the incidence of intestine cancer is increasing in the west part of China these years.

As learned in the biology class, water is an ecological factor to the creatures, and it is an integral aspect of agriculture and ecosystem services, but increasing demand has put serious pressures on its provision, availability and quality. 50 years ago, the world’s population was fewer than half the people of today. In general, people consumed fewer calories, including meat, and thus required one third of the water we now use. Today, freshwater withdrawals from lakes and rivers doubled (since 1960) with 70% worldwide used for agriculture. Reduced availability of water in many areas constrains food production, exacerbating hunger and poverty, and reduces other ecosystem services provided by water. Poor water quality has serious affects on human health and biodiversity and hence on ecosystem services. Regulating services of wetlands includes nutrient cycling and flood and pollution control, essential services for healthy environments and productive agriculture.

3. Feedbacks from the students:

After the class, one of the students wrote down a water song:

Water is life,

She can help us, and she can kill us too.
If we haven’t water, we will die quickly.
But, now water crisis is a big problem! The quality of water is worse and worse.
We don’t want to be the last generation!
We must save water! We must use water economically.
Human being.
Save every cup of water, save every drop of water!
Heal the world, and heal the water!
This is our mission.

Another student said: “Before the class, I think water crisis, like starvation and poverty, is seemingly far away from children in Beijing, especially us, who live in middle class families and think ourselves deserving good living conditions. Water crisis just threaten the people in the poor places. By this lecture, I know some children are dying because they lack of clean water. How can someone with conscience and sympathy watch the tragedy going on and do nothing? I will share this information with my friends, relatives and families. We should strengthen the consciousness to protect water.”

4. Significance of this course
This course provides a good opportunity to carry out environmental education. The students are getting to understand the principle of water ethics, and human play a vital role in water issues which is relating to each of the Chinese people's lives and relating to a nation's future and destiny. From October 14th to 21st, the Chinese Central TV News Channel launched a documentary "water cries", which also enhanced the teenage’ and the citizens’ responsibility to protect the water. The significance of that responsibility was nicely phrased by former Norwegian Prime Minister G.H. Brundtland: “We must consider our planet to be on loan from our children, rather than being a gift from our ancestors.”
Case Study 7 – Water Ethics Reflections in Eucalyptus Planting
(by Nesy Daniel, India)

Desertification and its consequence, famine, have already caused the death of over 900,000 people in Ethiopia. In the Sahel, 40 to 90 percent of the livestock has died. Nearer home, starvation deaths owing to water scarcity are a recurrent phenomenon in Rajasthan, Madhya Pradesh, and Orissa. Although officialdom has no eyes for it, and the 'free but cooperative press' of India - J. K. Galbraith's description - has no space for it, such deaths occasionally make a splash when a political bigwig is accidentally confronted by it, as happened during the Prime Minister's tour of drought-hit Orissa when a hapless woman named Parasi Punji made bold to tell the Prime Minister how drought had forced her to sell her sister-in-law for Rs 40 to feed her three starving children.

Since ancient times societies have known that forests are the best insurance against desertification and famine. The reductionist version of this response to desertification is itself a prescription for desertification. Under the World Food Programme, FAO is planting eucalyptus in Ethiopia. Under the social forestry schemes for ecological repair, the World Bank, SIDA, USAID have coaxed India into putting farmlands under eucalyptus. People who for centuries have been planters and protectors of trees have suddenly been marginalized. Knowledge of tree planting has become the sole preserve of international and national bureaucracies. Throughout the world, irrespective of local ecological conditions and economic needs, the prescription is only one - eucalyptus. The biological wealth and diversity of the tropics have been destroyed to make room for the reductionist solution, even though eucalyptus causes rather than cures deserts, upsets the cycle of life, the hydrological cycle and the nutrient cycle.

The ecological audit of eucalyptus plantations reveals that it involves heavy economic costs through the destruction of the hydrological stability and soil productivity in the following ways:

First, in regions which have water scarcity, the high water intake of eucalyptus destroys the natural processes that replenish soil moisture and recharge the sources of underground water, turning the region into a completely arid zone. Moreover, eucalyptus damages the innate allelomorphic capacity of all other plants, seriously depleting the gene pool. The process initiated by large-scale cultivation of eucalyptus in water-scarce regions therefore leads inexorably to desertification.

Second, on fertile agricultural lands, eucalyptus, when planted and harvested in short rotation, heavily diminishes soil nutrients, destroying the soil's capacity for biological productivity. Moreover, eucalyptus destroys the environment for soil fauna that are at once 'factories' for reproducing soil fertility, and efficient 'machines' for maintaining the soil structure.

In the countries of the South, desertification has become an increasingly severe threat to human survival. The recently published UNEP report on deserts estimates that about 3.5 million hectares of productive and fertile rain-fed land is being lost annually. The food crisis in Africa testifies to the cost of desertification in human and economic terms. It is also a reminder that many of the economic problems of the poorest of mankind are rooted in the
ecological destruction caused by excessive demands on the natural resources by the élites of the world.

Eucalyptus emerged as a magical candidate for all kinds of afforestation programmes during the 1960s because it is a fast-growing species. This belief was, however, challenged and it was shown that many indigenous species have higher growth rates than eucalyptus. It was then admitted that the whole question of fast growth has come to light only because of the pulp industry gaining importance. How to get adequate pulp quickly was our problem. It is with this reference that we had to try various species not only indigenous, but also exotic. While trying the exotics, we found the eucalyptus quite useful.

In spite of eucalyptus being fast-growing and productive only in the narrow context of wood-fibre production, it was prescribed as a universal means for achieving increased productivity of biomass for the satisfaction of diverse needs. And so, a reductionist view of forestry wedded to the pulp industry was universalized at the cost of conservation of soil and water.

The rapid decline, and even total destruction, of water resources as a consequence of large-scale planting of eucalyptus has been reported from all parts of India. Sunderlal Bahuguna recorded the following statement of an elderly forest ranger in the Nainital tarai of Uttar Pradesh: ‘We felled mixed natural forest of this area and planted eucalyptus.... Our handpumps have gone dry as the water-table has gone down. We have committed a sin.’ Mahashweta Devi described the impact of eucalyptus on the water resources in the tribal areas of Bihar and West Bengal in the following words: “I am concerned with the India I know. My India is of the poor, starving and helpless people. Most of them are landless and the few who have land are happy to be able to make most of the given resources. To cover Purulia, Bankura, Midnapur, Singbhum, Palamau, with eucalyptus will be to rob my India of drinking and irrigation water.”

On 10 August 1983, the farmers of Barka and Holahalli villages in Tumkur district, in Karnataka, marched en masse to the forest nursery and pulled out millions of eucalyptus seedlings, inserting tamarind and mango seeds in their place. According to them, eucalyptus plantation in the catchment area of the streams feeding their agricultural land had made them go dry. Describing the state of the main stream feeding the village Guttalagolahalli, a local farmer complained, “Earlier we would take our cattle to this stream in the summer. But now, as the stream is dry, we have to fetch water from a well.”

Yet, forestry experts refuse to accept this, presumably because it hurts their own dominance and that of the interests they serve. The president of the Forest Research Institute of India, K. M. Tiwari, and R. S. Mathur, in a paper published in a special issue of the Indian Express, writes: “Of late in India a lot of controversy has arisen over the water consumption behaviour of eucalyptus planted in afforestation programmes in social forestry. It has been alleged that eucalyptus plantation consumes large quantities of water to the extent that they deplete local water resources such as streams, wells, etc. This notion does not appear to be correct, as no experimental data in support has so far been presented.... There is no scientific basis in the popular fallacy that eucalyptus lowers the ground-water table.”

Scientific fact and empirical reality have thus been conveniently reduced to a fallacy. With the help of a controlled experiment, the foresters have manufactured a new justification for the propagation of eucalyptus. Having found that all recognized and established scientific
information was delegitimizing eucalyptus as a fast-growing tree, the forest establishment in India has rejected these data and initiated their 'controlled' experiments after the emphasis on eucalyptus in Indian social forestry was challenged in 1981. The Forest Department of Uttar Pradesh produced some data in 1983 on the biomass production of a few tree species, including eucalyptus hybrid (Table 1).

The data of this single-plant experiment on one-year-old juveniles became the proverbial straw the official foresters clutched at to legitimize the bias of their kind in favour of eucalyptus. This gave the green signal to all eucalyptus plantations, in all agro-climatic conditions, in all parts of the country. In the history of forestry science in the world there is no parallel to this unrealistic extrapolation of a juvenile single-plant data to large-scale afforestation programmes unmindful of the well-established fact of non-uniform growth rates of eucalyptus at different ages.

One can easily see the inapplicability of the Kanpur data to mature trees. Eucalyptus, the low leaf litter of which is well known from measurements made in plantation studies, comes out as the best leaf producer in the Kanpur 'controlled' experiment. *Pongamia pinnata*, which is famous for its high crown biomass output, is reduced, in the Kanpur experiment, to a tuber crop with extremely low crown biomass output, less even than its root. The much advertised Kanpur data does not reflect the field reality and does not satisfy minimum scientific criteria. Reflecting on this point, D. R. Bhumla, a renowned agricultural scientist, at a Planning Commission meeting on eucalyptus, cautioned: “There are no data to show that eucalyptus produced more biomass than other species like *Acacia nilotica*, *Dalbergia sissoo* and *Prosopis juliflora*. Hence there was no strong case for advocating eucalyptus in social and farm forestry. However, it might be useful for pulp production on unirrigated lands, raising eucalyptus plantation would result in disaster. The poor and marginal farmers should be provided with enough data on eucalyptus before persuading them to take to eucalyptus.”

Reductionist forestry science is intimately linked to forest-based industry, notwithstanding its claim to be “objective”. When its violence to nature through desertification, and its violence to man through famine, is exposed, official foresters turn on the victims of desertification and accuse them of colossal ignorance of the science of forestry. But this science does not balk at manufacturing data to legitimize misinformation; it violates the tradition of science itself to deny people the right to know and to hide, under the protective umbrella of the state, the nexus between modern science and capital accumulation.

<table>
<thead>
<tr>
<th>Species</th>
<th>Water consumed in 1 yr (litres)</th>
<th>Biomass production (gm)</th>
<th>Total biomass produced/litre of water (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shoots</td>
<td>Roots</td>
</tr>
<tr>
<td><em>Acacia auriculaciformis</em></td>
<td>1231.50</td>
<td>1023.5</td>
<td>361.6</td>
</tr>
<tr>
<td><em>Albizzia lebbeck</em></td>
<td>1283.90</td>
<td>1132.4</td>
<td>085.6</td>
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<td><em>Dalbergia sissoo</em></td>
<td>1534.05</td>
<td>1129.3</td>
<td>775.5</td>
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<td><em>Pongamia pinnata</em></td>
<td>459.15</td>
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<td><em>Syzigium cumhi</em></td>
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<td><em>Eucalyptus hybrid</em></td>
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<td>2519.8</td>
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